Report on Environmental Conditions in the Chesapeake Bay and Its Tributaries

2004 Annual Report from the Secretary of Natural Resources on Virginia's Chesapeake Bay Program:

Environmental Conditions and Water Quality Status and Trends

November 2004

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I. INTRODUCTION AND OVERVIEW

This section presents a very general overview of selected water quality conditions in the tidal portions of the Virginia Chesapeake Bay and its major tributary basins (Potomac, Rappahannock, York, James, and Eastern Shore). Much more comprehensive and detailed analyses are available for each major Bay basin by contacting the Department of Environmental Quality's Chesapeake Bay Program.

Water quality conditions are presented here through a combination of the current status and long-term trends for nutrients (nitrogen and phosphorus), chlorophyll, water clarity, suspended solids, and dissolved oxygen. These are the water quality indicators most directly affected by nutrient and sediment reduction strategies.

The Virginia Chesapeake Bay and its tidal tributaries continue to show environmental trends indicating progress toward restoration to a more balanced and healthy ecosystem. However, the Bay system remains stressed and some areas and indicators show continuing degradation. Progress in reducing nutrient inputs has made demonstrable improvements and it is expected that continued progress toward nutrient reduction goals, along with appropriate fisheries management and chemical contaminant controls, will result in additional improvements to the Bay. Findings from the last 19 years (1985 through 2003) of the monitoring programs are highlighted below and discussed further in the following sections.

- Overall, in Virginia's portion of the Chesapeake Bay drainage area, the 2003 annual nutrient loads discharged by significant point sources were reduced by 53% for phosphorus and 30% for nitrogen, compared to 1985 baseline loads.

- Estimates for the delivered loads of phosphorus, nitrogen and sediment from nonpoint sources, as calculated by the Bay Program Watershed Model, have decreased by 13%, 11%, and 12%, respectively, compared to 1985 levels.

- Phosphorus levels in water entering from the Bay watershed are reflecting both point and nonpoint source nutrient source reductions by showing improving concentration trends in some rivers, while degrading in others. Within the tidal waters themselves there are several areas showing improvement but also some degrading areas. Overall, there were eight areas showing improving trends and ten areas showing degrading trends for phosphorus.

- For nitrogen, the Potomac shows improving trends in water entering from the watershed. Nitrogen levels also showed improving trends in much of the tidal rivers and the Chesapeake Bay. Degrading trends are a concern in the upper Pamunkey River. Overall, there were thirteen areas showing improving trends and only one area showing degrading trends for nitrogen.

- Chlorophyll concentrations (an indicator of algae levels) are relatively poor throughout parts of Virginia's tidal waters. There were widely scattered areas of improving and degrading trends. Overall, five areas showed degrading trends in chlorophyll and five areas showed an improving trend. These results indicate nutrient concentrations are still too high despite relatively widespread improving trends in nitrogen. Initial assessment of recently proposed regulatory criteria (revised tidal water quality standards) indicates fairly widespread areas of non-attainment in the James River.

- Levels of dissolved oxygen are improving in geographically widespread areas of the tidal rivers. However, an assessment of oxygen conditions in relation to recently proposed regulatory criteria shows many areas of impairment. Overall, there were eight areas showing improving trends and one area showing degrading trends for dissolved oxygen conditions.

- Water clarity, a very important environmental parameter for the growth and survival of underwater grasses, was generally fair and degrading trends were detected in many areas. This degradation is probably related to scattered areas of increasing levels of suspended solids. These degrading conditions are a major impediment to restoration of submerged aquatic vegetation (SAV). Overall, there are twelve areas showing degrading trends and no areas showing improving trends in water clarity. An initial assessment of recently proposed regulatory criteria indicates fairly widespread areas of non-attainment.

- The Elizabeth River is showing improving trends in most major water quality parameters.

- Water quality in creeks and inlets of Virginia's Eastern Shore indicates high groundwater nutrient levels, most likely due to agricultural activities.

- In summary, there are generally improving conditions for nitrogen and dissolved oxygen and degrading conditions for water clarity. Other parameters show a roughly equal mix of both improving and degrading trends. These patterns are a combined result of both management controls of nutrient inputs and the natural effects of rainfall (e.g., the drought that ended in 2003).

II. TRIBUTARY BASIN NUTRIENT LOADS

A. Point Sources

Table II-1 presents the annual nitrogen and phosphorus loads discharged by the significant point sources into each of Virginia's Bay tributary basins during calendar year 2003. The table also shows the percent change in loads from 1985 to 2003.

Overall, between 1985 and 2003, the annual point source nutrient loads discharged into Virginia's Bay watershed have been reduced by 53% for phosphorus, and 30% for nitrogen. Although point source phosphorus loadings are still much lower than the 1985 baseline, a slight increasing trend is becoming evident in recent years due to a rise in the amount of wastewater treated. The significant reductions achieved by the phosphate detergent ban and installation of chemical phosphorus removal systems (at major plants subject to the Point Source Policy for Nutrient Enriched Waters) are beginning to be offset by the increased flows. This trend is likely to continue until additional plants implement phosphorus removal or more stringent treatment levels are achieved. The total nitrogen load from point sources decreased 5% from 2002 to 2003, with a significant change seen in the Potomac basin where the load was reduced by about 1.7 million pounds/year. This is largely due to the start-up of biological nutrient removal (BNR) at several municipal wastewater plants, and a full year of BNR operation at some of the largest facilities in the northern Virginia area, including Alexandria, Fairfax County, and the Dale Service Corporation. It is anticipated that future discharge figures will show even further reductions as these systems are fine-tuned and optimized.

Appendix A contains the 2003 nutrient loads for the significant point source dischargers tracked in each river basin in Virginia's portion of the Chesapeake Bay watershed. Plants are sorted by the percent reduction achieved since the baseline year (1985), with those achieving the highest reduction levels at the top of each list.

Table II-1. Virginia Point Source Discharged Nutrient Loads – 2003

River Basin*	Number Of Plants	2003 Phosphorus Load (lbs/yr)	Phosphorus % Change from 1985	2003 Nitrogen Load (lbs/yr)	Nitrogen % Change from 1985
Shen./Potomac	39	521,950	-32%	7,290,460	-33%
Rappahannock	18	70,700	-63%	688,260	+24%
York	10	171,870	-62%	1,157,350	-17%
James	37	1,723,860	-55%	17,033,710	-30%
Eastern Shore	5	7,680	-81%	234,120	-18%
Totals	**109**	**2,496,060**	**-53%**	**26,403,900**	**-30%**

*Note: Loads from dischargers located in the Small Western Coastal Basins are included with the nearby major tributary loads (Rappahannock includes Wicomico and N. Neck coastal; York includes Piankatank and Mobjack; James includes Poquoson, Back, Little Creek and Lynnhaven basins).

B. Nonpoint Sources

Table II-2 presents the 2003 loading estimates for phosphorus, nitrogen and sediment from nonpoint sources in each of Virginia's tributary basins. The nonpoint source categories include runoff from agricultural, urban, mixed open, and forested lands, along with septic systems and air deposition to non-tidal waters. The table also shows the percent change in loads compared to the 1985 baseline. These loading figures are based on the Year 2003 Progress Simulation Run of the Chesapeake Bay Watershed Model (Version 4.3). The Progress Simulation scenario provides an estimate of the projected nutrient and sediment reductions towards the cap load allocation in any given year, based on the reported cumulative implementation of control measures (nonpoint source Best Management Practices) for that year. Further, the simulation of lag times in groundwater nitrogen and sediment transport is somewhat limited in the Watershed Model, so the Progress Simulation scenario estimates are best interpreted as a total annual nonpoint source load, assuming average hydrologic conditions, which will occur sometime in the future.

Table II-2. Virginia Nonpoint Source Delivered Nutrient & Sediment Loads – 2003

River Basin	2003 Phosphorus Load (lbs/yr)	Phosphorus % Change from 1985	2003 Nitrogen Load (lbs/yr)	Nitrogen % Change from 1985	2003 Sediment Load (tons/yr)	Sediment % Change from 1985
Shen./Potomac	1,560,050	-15%	14,440,810	-6%	713,570	-14%
Rappahannock	873,590	-19%	7,189,170	-22%	332,430	-21%
York	602,740	-17%	6,420,150	-16%	125,770	-20%
James	4,108,000	- 10%	21,886,000	- 7%	1,166,650	- 8%
Coastal	194,070	-14%	1,944,400	- 11%	21,920	-6%
Totals	**7,338,450**	**- 13%**	**51,880,530**	**- 11%**	**2,360,330**	**-12%**

III. Water Quality

Monitoring of water quality conditions is vital to understanding environmental problems, developing management strategies, and assessing progress toward environmental quality restoration. This section summarizes results of statistical analyses conducted on surface concentrations of total nitrogen, total phosphorus, chlorophyll, water clarity, total suspended solids and bottom measurements of dissolved oxygen. These parameters are measures of water quality that are directly influenced by changes in nutrient loading and that in turn directly affect living resources of the Bay.

Nutrients such as nitrogen and phosphorus influence the growth of phytoplankton in the water column. Elevated concentrations of these nutrients often result in excessive phytoplankton production (i.e., chlorophyll). Decomposition of the resulting excess organic material during the summer can result in low levels of dissolved oxygen in bottom waters. These low oxygen levels (anoxic or hypoxic events) can cause fish kills and drastic declines in benthic communities which are the food base for many fish populations. Anoxic waters also adversely affect fish and crab population levels by limiting the physical area available where these organisms can live.

The terms ***good***, ***fair***, and ***poor*** used in conjunction with nitrogen and phosphorus conditions are statistically-determined classifications for comparison among areas of similar salinity within the Chesapeake Bay system. Though useful in comparing current conditions among different areas of the Chesapeake Bay system, it must be remembered that these terms are not absolute evaluations but only appraisals relative to other areas of a generally degraded system. Several major scientific studies have shown that the Chesapeake Bay system is currently nutrient enriched and has excessive and detrimental levels of nutrient and sediment pollution. Given this, it is likely that an absolute evaluation in relation to ideal conditions would indicate that most water quality parameters are currently poor throughout the whole Bay system.

The Monitoring Subcommittee of the Federal-Interstate Chesapeake Bay Program continues to develop additional methodologies for water quality status evaluations, which in the future will be used in conjunction with, or possibly in replacement of, the current methods.

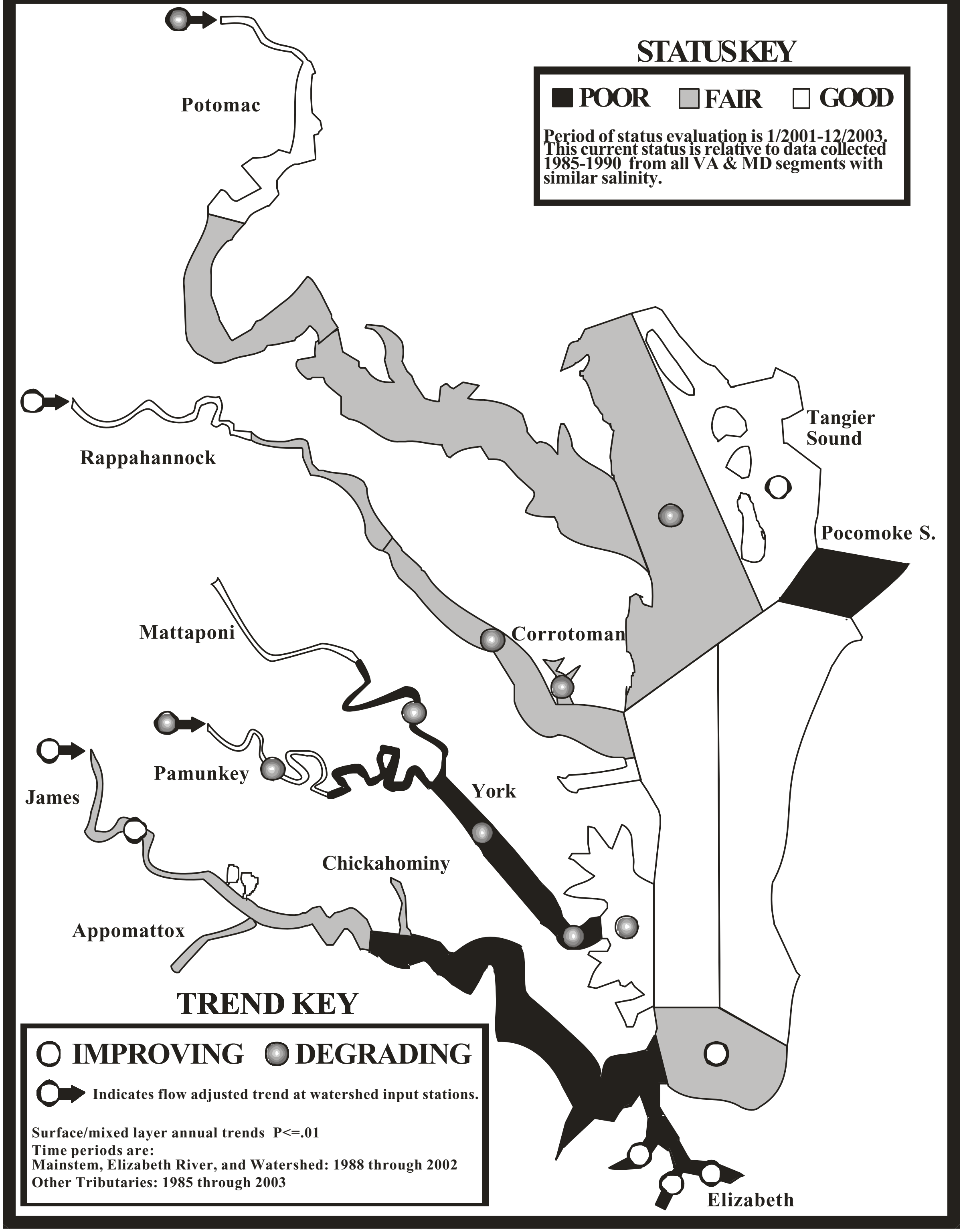
Phosphorus: Figure 1 presents current status and long term trends in phosphorus concentrations. Areas of the **Elizabeth,** lower **James, York**, and **Pocomoke** sound have the poorest conditions in relation to the rest of the overall Chesapeake Bay system. Other segments have fair status but much of the mainstem **Chesapeake Bay** and the upper portions of the tidal rivers have relatively good conditions.

The “watershed input” stations shown in Figure 1 provide information about the success of nutrient control efforts. Results at these watershed input monitoring stations are flow-adjusted in order to remove the effects of river flow and assess only the effect of nutrient management actions (e.g., point source discharge treatment improvements and BMPs to reduce non-point source runoff).

The watershed input stations in two of the largest Virginia tributaries (**James** and **Rappahannock**) show improving concentration trends. Unfortunately, degrading trends for **Pamunkey** and **Potomac** watershed inputs are still present. The degrading trend in phosphorus at the **Pamunkey** watershed input station and degrading trends in parts of the **Mattaponi**, **Pamunkey**, and **York** suggest management efforts to control phosphorus have not been as effective or implemented as widespread in this basin.

The lower **Rappahannock** and **Corrotoman** Rivers and part of the **Chesapeake Bay** also have degrading trends. The **James** and **Elizabeth** Rivers as well as a few areas of the **Chesapeake Bay** show improving conditions for phosphorus. The improving conditions for phosphorus in the **James** and **Elizabeth** mirrors the improving nitrogen trends there as well.

Figure 1) Total Phosphorus Status and Trends



Period of status evaluation is 1/2001-12/2003. This current status is relative to data collected 1985-1990 from all VA & MD segments with similar salinity.

Indicates flow adjusted trend at watershed input stations.

Surface/mixed layer annual trends P<=.01
Time periods are:
Mainstem, Elizabeth River, and Watershed: 1988 through 2002
Other Tributaries: 1985 through 2003

Nitrogen: Figure 2 presents status and long term trends in nitrogen concentrations. Status of nitrogen in the upper **Potomac** and parts of the **Elizabeth** River is worse than status in the other major tributaries and the **Virginia Chesapeake Bay**. Much of the **Rappahannock**, **York,** and **James** Rivers as well as the **Virginia Chesapeake Bay** have good relative status.

The largest tributary (**Potomac**) has improving trends in the water entering from its watershed. As with phosphorus, flow-adjusted concentrations of nitrogen are degrading in the **Pamunkey** River. The remaining rivers do not show any trends in the flow adjusted concentrations at river input sites.

There are relatively widespread improving nitrogen trends in the tidal waters. This is particularly evident in the upper **James**, **Potomac**, and **Elizabeth** Rivers. Much of the mainstem **Chesapeake Bay** also has improving trends. These improvements are a result of both the nutrient management efforts and natural factors. The major natural factor has been the overall long-term (i.e., 1985 through 2002) declining riverflow at the watershed input stations of the **Rappahannock**, **Pamunkey**, **Mattaponi**, **James**, and **Appomattox** rivers. These widespread improving nutrient trends are very encouraging, however, the lack of widespread improvements in algal populations or dissolved oxygen (see following discussions) indicate that nutrient levels remain detrimentally high.

Chlorophyll: Chlorophyll is a measure of the level of algal biomass (i.e., phytoplankton) in the water. High chlorophyll or algal levels indicate poor water quality because they can lead to low dissolved oxygen conditions when the organic material sinks into bottom waters and is decomposed. High algal levels can also be a factor in reduced water clarity which decreases available light required to support photosynthesis in Submerged Aquatic Vegetation (SAV). High algal levels also are indicative of problems with the food web such as decreased food quality for some fish (e.g., menhaden) and shellfish (e.g., oysters) due to a dominance of small or undesirable types of algae. Finally, high levels of chlorophyll may be indicative of large-scale blooms of toxic or nuisance forms of algae.

Figure 3 presents the current status and long term trends in chlorophyll concentrations. Parts of all of the major Virginia tributaries have poor status in relation to Bay-wide conditions.

Degrading trends in chlorophyll were detected in the areas of **Tangier Sound** as well as the **Potomac** and **Rappahannock** Rivers. Improving trends were observed in the **Mobjack** Bay and part of the **Elizabeth**, River.

Chlorophyll in relation to new Bay criteria: One key water quality commitment in the *Chesapeake 2000 Agreement* is to correct the nutrient- and sediment-related problems in the Chesapeake Bay and its tidal tributaries, by the year 2010, sufficiently to remove the Bay and the tidal portions of its tributaries from the list of impaired waters under the Clean Water Act.

The first step in this process was to define appropriate regulatory criteria by which the Bay should be assessed. The U.S. Environmental Protection Agency (EPA) Region III developed a guidance document, entitled "Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll *a* for the Chesapeake Bay and Its Tidal Tributaries (April 2003)". This document presents the EPA's proposed regional-based nutrient and sediment enrichment criteria expressed as dissolved oxygen, water clarity and chlorophyll *a* criteria, applicable to the Chesapeake Bay and its tidal tributaries. In regards to chlorophyll *a*, the document states:

> “The EPA expects states to adopt narrative chlorophyll *a* criteria into their water quality standards for all Chesapeake Bay and tidal tributary waters. The EPA strongly encourages states to develop and adopt site-specific numerical chlorophyll *a* criteria for tidal waters where algal-related impairments are expected to persist even after the Chesapeake Bay dissolved oxygen and water clarity criteria have been attained. The Chesapeake Bay Program partners developed a general methodology for possible use by the jurisdictions with tidal waters to determine consistently which local tidal waters will likely attain the published Chesapeake Bay dissolved oxygen and water clarity criteria yet algal-related water quality impairments will persist.”

The proposed Virginia narrative criteria for Chesapeake Bay and it’s tidal waters is: “*Concentrations of chlorophyll a in free-floating microscopic aquatic plants (algae) shall not exceed levels that result in undesirable or nuisance aquatic plant life, or render tidal waters unsuitable for the propagation and growth of a balanced, indigenous population of aquatic life or otherwise result in ecologically undesirable water quality conditions such as reduced water clarity, low dissolved oxygen, food supply imbalances, proliferation of species deemed potentially harmful to aquatic life or humans or aesthetically objectionable conditions*”.

While this narrative criteria is universally applicable, specific numerical criteria are being proposed for the **James** River because of the EPA guidance quoted above that: “The EPA strongly encourages states to develop and adopt site-specific numerical chlorophyll *a* criteria for tidal waters where algal-related impairments are expected to persist even after the Chesapeake Bay dissolved oxygen and water clarity criteria have been attained”. As discussed in following sections of this document, the **James** River is expected to currently be in attainment of dissolved oxygen and possibly water clarity criteria. However, extensive analyses of monitoring data from the **James** River has shown that there are currently “*undesirable or nuisance aquatic plant life, … unsuitable for the propagation and growth of a balanced, indigenous population of aquatic life… food supply imbalances”,* and *“… proliferation of species deemed potentially harmful to aquatic life”* (Recommendations for Chlorophyll a Numerical Criteria: Arthur Butt, Elleanore Daub, Rick Hoffman, July 2004).

The proposed chlorophyll criteria are shown in Table III-1. Figure 3a shows an evaluation of where these criteria are attained based upon data collected during of the time period of 1984 through 1995.

- Full attainment of the criteria was achieved in the upper **James** during both the spring and summer seasons and in the lower **James** during the summer season.

- The spring season had the most aerially widespread area of non-attainment.

- Non-attainment was worst (i.e., about 63%) in the lower tidal fresh segment (Hopewell region) during summer and the lower segment at the river mouth (Norfolk region) during spring.

There are several caveats to this assessment. First, this assessment is based on a ten-year data period (1985 – 1995) and is not reflective of current conditions or the proposed three-year data period (2001 – 2003) used to present the status for other parameters in this report. Finally, the complete regulatory assessment methodology (including data interpolation methods and data analysis tools) is still under development. It is expected that these will be finalized during 2005. With these caveats, this demonstrates the new process that will be used in defining a realistic regulatory framework for Chesapeake Bay restoration.

Table III-1) Summary of mean chlorophyll *a* (*u*g liter^{-1}) concentrations with site-specific proposed numerical criteria for Chesapeake Bay segments, JMSTF2, JMSTF1, JMSOH, JMSMH, and JMSPH by season.

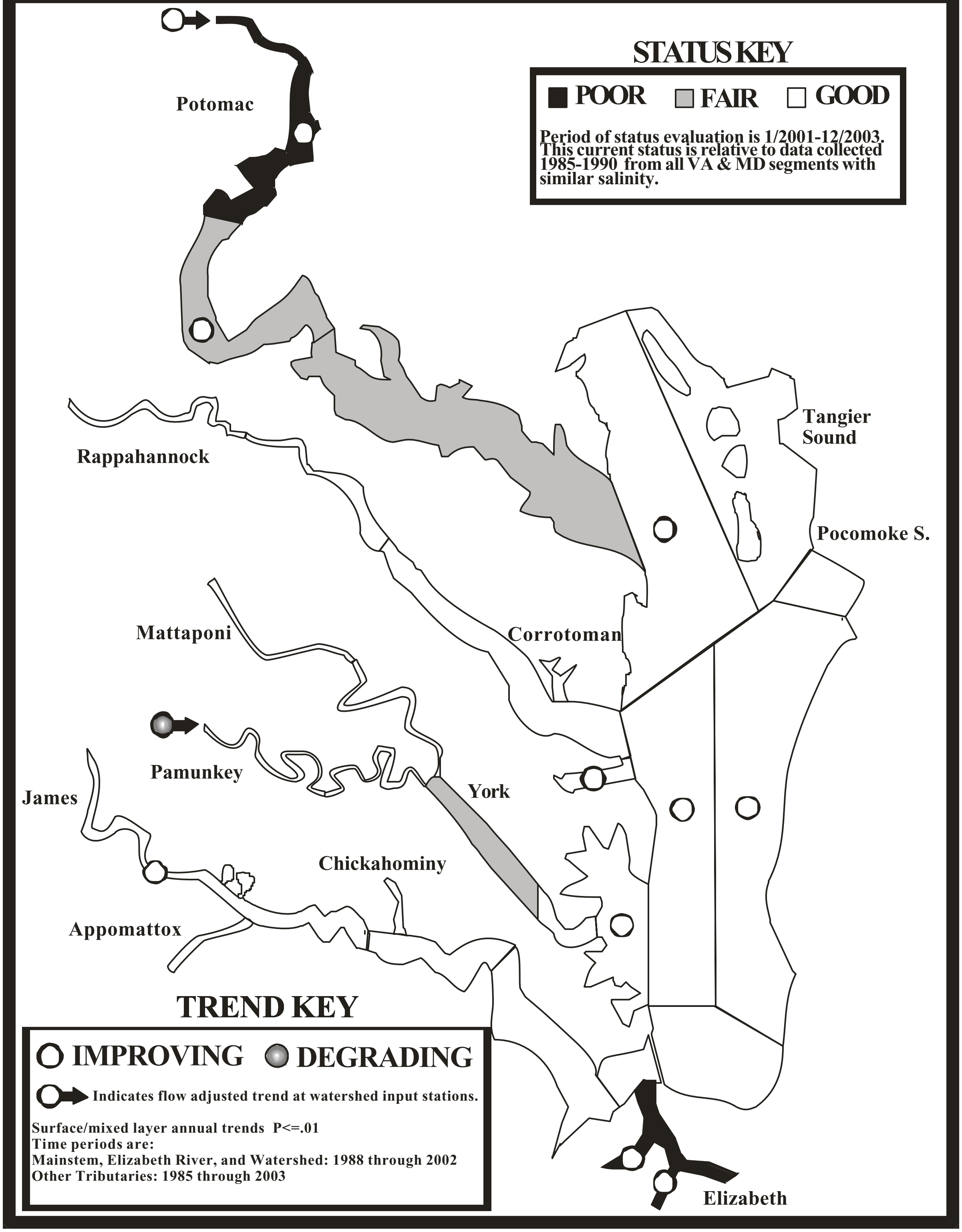
Salinity Regime	Historical Conc.(1)	Supports D.O. Criteria.(2)	Attainable Conc. James(3)	EPA Recommended Conc.(4)	Reference Community Conc.(5)	**VA Proposed Conc.** (6)	Current Conc. (90%)(7)	Harmful Algal Bloom Conc.(8)	HAB Threshold Conc.(9)
Spring (March 1 - May 31)									
JMSTF2	3.7	4	<6	< 10	< 14	**10**	5 (11)	NA	-
JMSTF1	3.7	4	<10	< 10	< 14	**15**	18 (45)	NA	-
JMSTOH	5.9	5	<9	< 10	< 21	**15**	13 (34)	NA	-
JMSTMH	7.2	6	<8	< 5	< 6	**10**	11 (23)	NA	-
JMSTPH	4.1	5	<9	< 5	< 3	**10**	11 (29)	>25	-
Summer (July 1 – September 30)									
JMSTF2	7.0	12	<10	< 15	< 12	**15**	10 (26)	> 15	25-30
JMSTF1	7.0	12	<17	< 15	< 12	**20**	28 (54)	> 15	25-30
JMSTOH	7.6	7	<12	< 15	< 9.5	**15**	8 (16)	NA	-
JMSTMH	7.9	5	<6	< 5	< 7.5	**10**	6 (10)	NA	-
JMSTPH	3.7	4	<6	< 5	< 4.5	**10**	10 (15)	> 25	-

Source: Recommendations for Chlorophyll a Numerical Criteria: Arthur Butt, Elleanore Daub, Rick Hoffman, July 2004

Dissolved Oxygen: Bottom dissolved oxygen levels are an important factor affecting the survival, distribution, and productivity of aquatic living resources. Figure 4 presents the current status and long term trends in dissolved oxygen concentrations. Status is given in relation to dissolved oxygen levels supportive or stressful to living resources. About half of the Virginia **Chesapeake Bay** and smaller portions of the tidal tributaries had only fair status. The lower **Potomac** River, lower **Rappahannock** River, lower **York** River, and northernmost Virginia **Chesapeake Bay** segments are indicated as poor or fair partly because of low dissolved oxygen concentrations found in the mid-channel trenches. These mid-channel trenches have naturally lower dissolved oxygen levels and the spatial and temporal extent of low dissolved oxygen levels has been made worse by excess nutrient inputs.

There are a few scattered areas of improving conditions for dissolved oxygen, with no degrading trends. These improvements are a result of both the nutrient management efforts and natural factors. The major natural factor has been the long-term (i.e., 1985 through 2003) declining riverflow at the watershed input stations of the **Rappahannock**, **Pamunkey**, **Mattaponi**, **James**, and **Appomattox** rivers. This in turn has lead to naturally less nutrient inputs and concurrently higher influxes of cleaner oceanic water. The relative lack of improvements in dissolved oxygen indicates that although nutrient concentrations have been improving in many areas (especially for nitrogen), there is still a need for significant reductions to occur.

Figure 2) Total Nitrogen Status and Trends



Period of status evaluation is 1/2001-12/2003. This current status is relative to data collected 1985-1990 from all VA & MD segments with similar salinity.

Indicates flow adjusted trend at watershed input stations.

Surface/mixed layer annual trends P<=.01
Time periods are:
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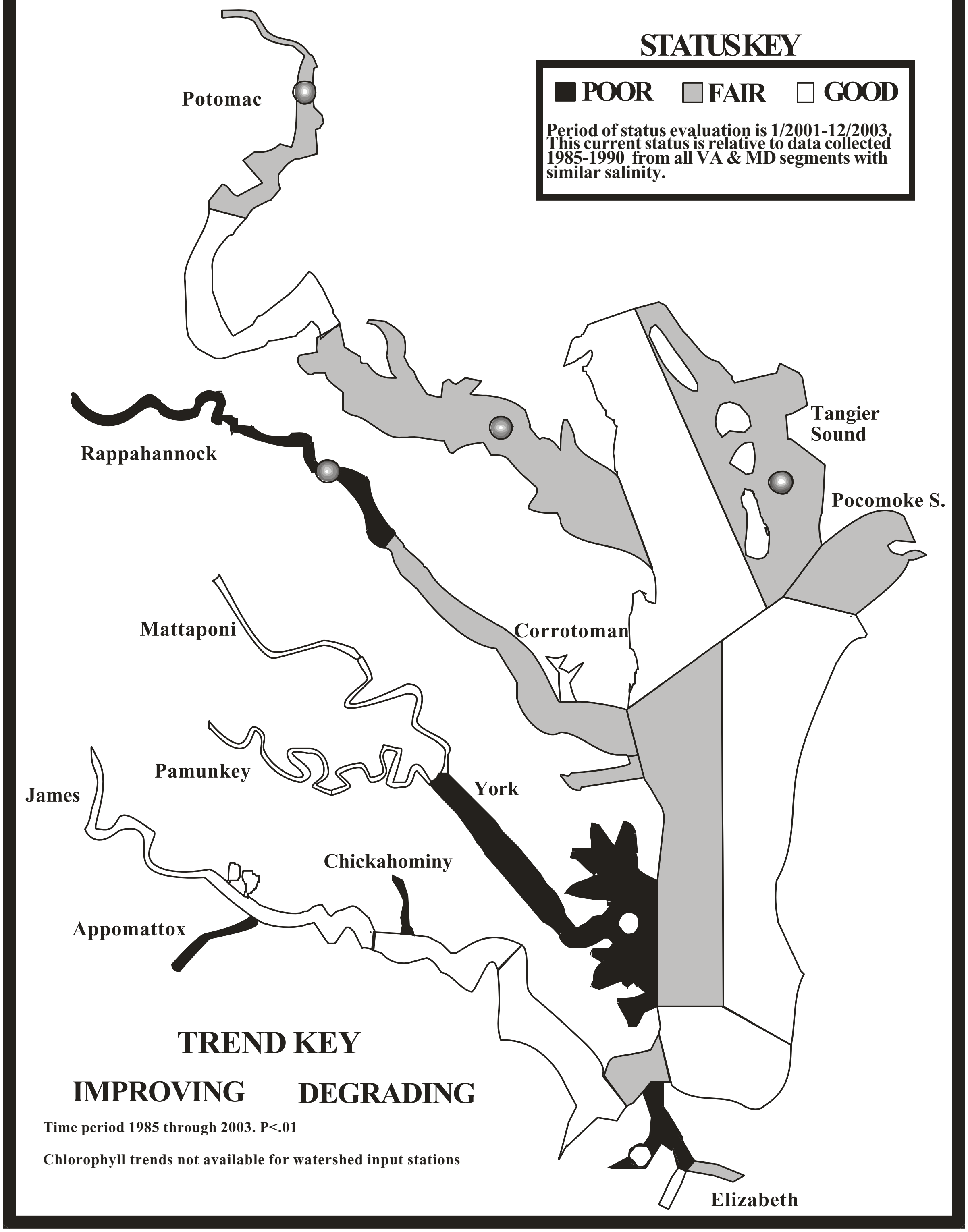
Figure 3) Chlorophyll Status and Trends



Period of status evaluation is 1/2001-12/2003. This current status is relative to data collected 1985-1990 from all VA & MD segments with similar salinity.

Time period 1985 through 2003. P<.01

Chlorophyll trends not available for watershed input stations

Figure 3A) Chlorophyll Criteria Attainment

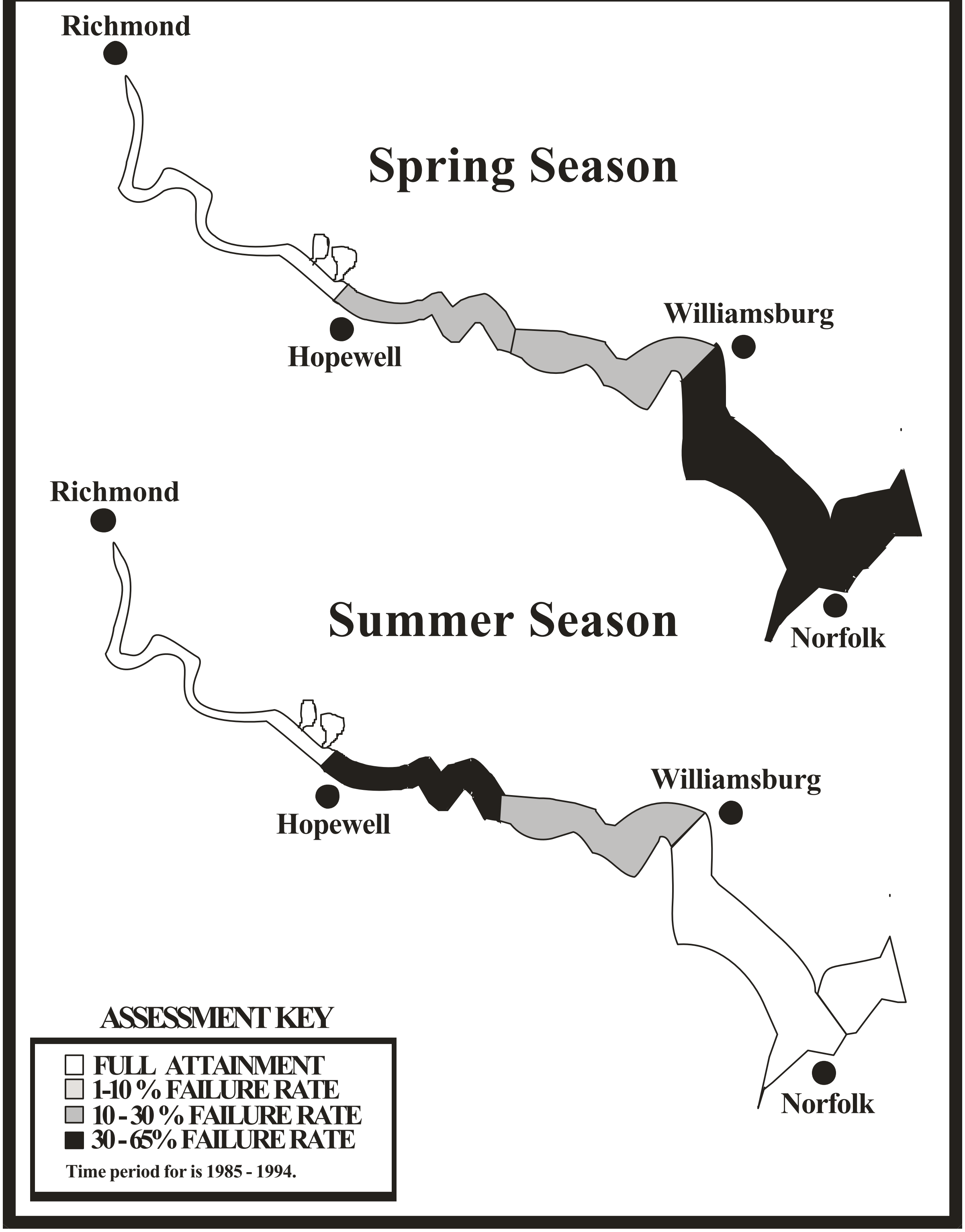
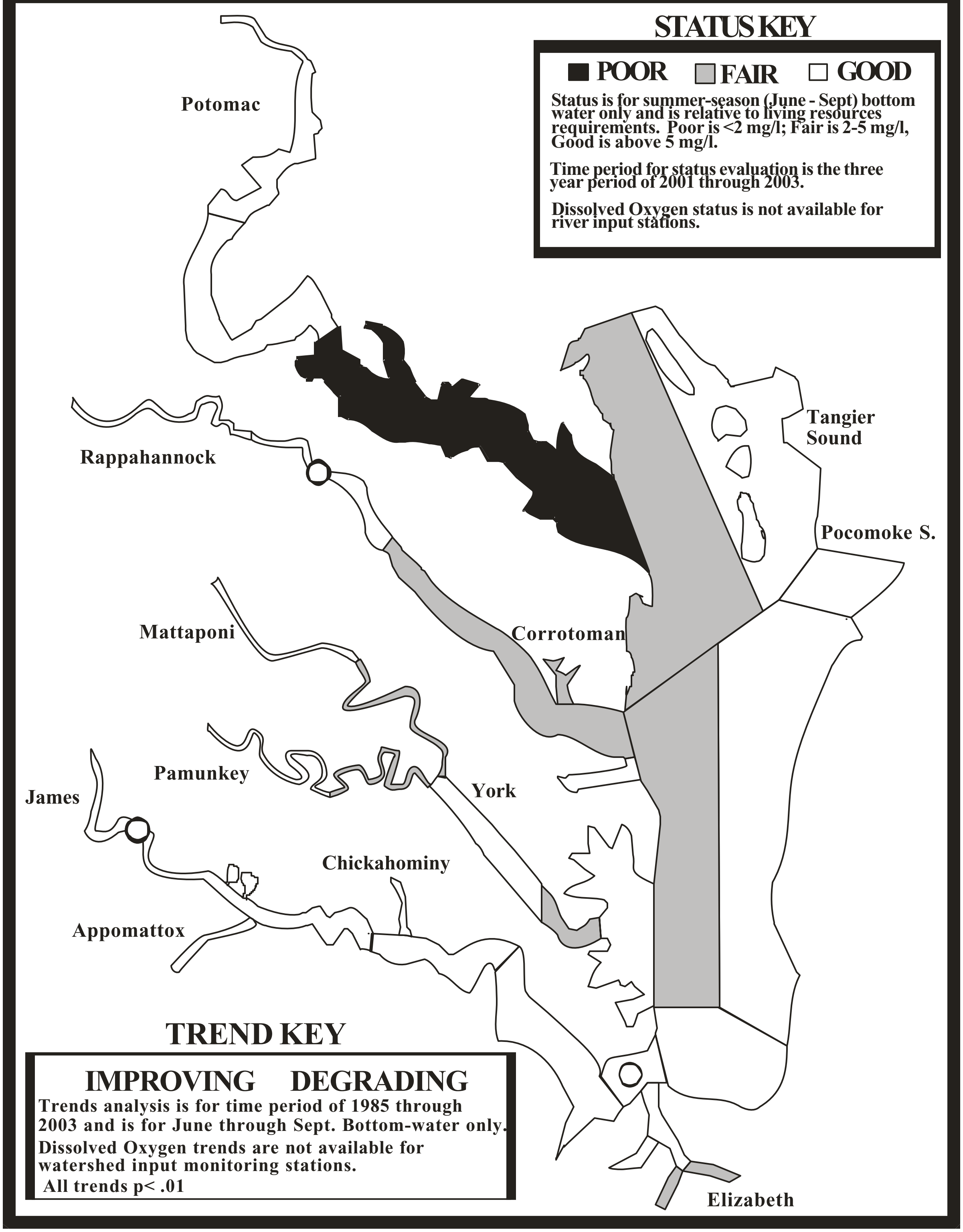


Figure 4) Dissolved Oxygen Status and Trends



STATUS KEY

■ **POOR** ▨ **FAIR** ☐ **GOOD**

Status is for summer-season (June - Sept) bottom water only and is relative to living resources requirements. Poor is <2 mg/l; Fair is 2-5 mg/l, Good is above 5 mg/l.

Time period for status evaluation is the three year period of 2001 through 2003.

Dissolved Oxygen status is not available for river input stations.

TREND KEY

IMPROVING DEGRADING

Trends analysis is for time period of 1985 through 2003 and is for June through Sept. Bottom-water only.

Dissolved Oxygen trends are not available for watershed input monitoring stations.

All trends p< .01

Dissolved Oxygen in relation to new Bay criteria: One key water quality commitment in the *Chesapeake 2000 Agreement* is to correct the nutrient- and sediment-related problems in the Chesapeake Bay and its tidal tributaries, by the year 2010, sufficiently to remove the Bay and the tidal portions of its tributaries from the list of impaired waters under the Clean Water Act.

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Current Virginia water quality standards require a monthly average dissolved oxygen level of 5 mg/liter throughout all of the Bay's waters – from the deep trench near the Bay's mouth to the shallows at the head of the Bay. Even though the 5 mg/liter standard is Bay-wide, scientists believe natural conditions dictate that in some sections of the Bay, such as the deep channel, waters cannot achieve the current 5 mg/liter standard during the warmer months of the year. Additionally, scientists believe other critical habitat areas, such as prime migratory fish spawning areas, require higher levels of dissolved oxygen to sustain life during the late winter to early summer time frame. The amount of oxygen needed in the Bay tidal waters depends on specific needs of the aquatic living resources, where they live, and during which time of the year they live there. Because of these factors, five revised Chesapeake Bay tidal water designated uses were developed to reflect the different aquatic living resource communities inhabiting a variety of habitats and, therefore, the different intended aquatic life use of those tidal habitats. The habitat designated uses are described below and graphically depicted in Figure 5.

Migratory Fish Spawning and Nursery Designated Use: Aims to protect migratory finfish during the late winter/spring spawning and nursery season in tidal freshwater to low-salinity habitats. This habitat zone is primarily found in the upper reaches of many Bay tidal rivers and creeks and the upper mainstem Chesapeake Bay and will benefit several species including striped bass, perch, shad, herring and sturgeon.

Shallow Water Designated Use: Designed to protect underwater Bay grasses and the many fish and crab species that depend on the shallow-water habitat provided by grass beds.

Open-Water Fish and Shellfish Designated Use: Designed to protect water quality in the surface water habitats within tidal creeks, rivers, embayments and the mainstem Chesapeake Bay year-round. This use aims to protect diverse populations of sport-fish, including striped bass, bluefish, mackerel and seatrout, bait fish such as menhaden and silversides, as well as the shortnose sturgeon.

Deep-Water Seasonal Fish and Shellfish Designated Use: Aims to protect living resources inhabiting the deeper transitional water column and bottom habitats between the well-mixed surface waters and the very deep channels during the summer months. This use protects many bottom-feeding fish, crabs and oysters, as well as other important species, including the bay anchovy.

Deep Channel Seasonal Refuge Designated Use: Designed to protect bottom sediment-dwelling worms and small clams that act as food for bottom-feeding fish and crabs in the very deep channel in summer. The deep-channel designated use recognizes that low dissolved oxygen conditions prevail in the deepest portions of this habitat zone and will naturally have very low to no oxygen during the summer.

Figure 5) Conceptualized illustration of the five Chesapeake Bay tidal water Designated Use zones

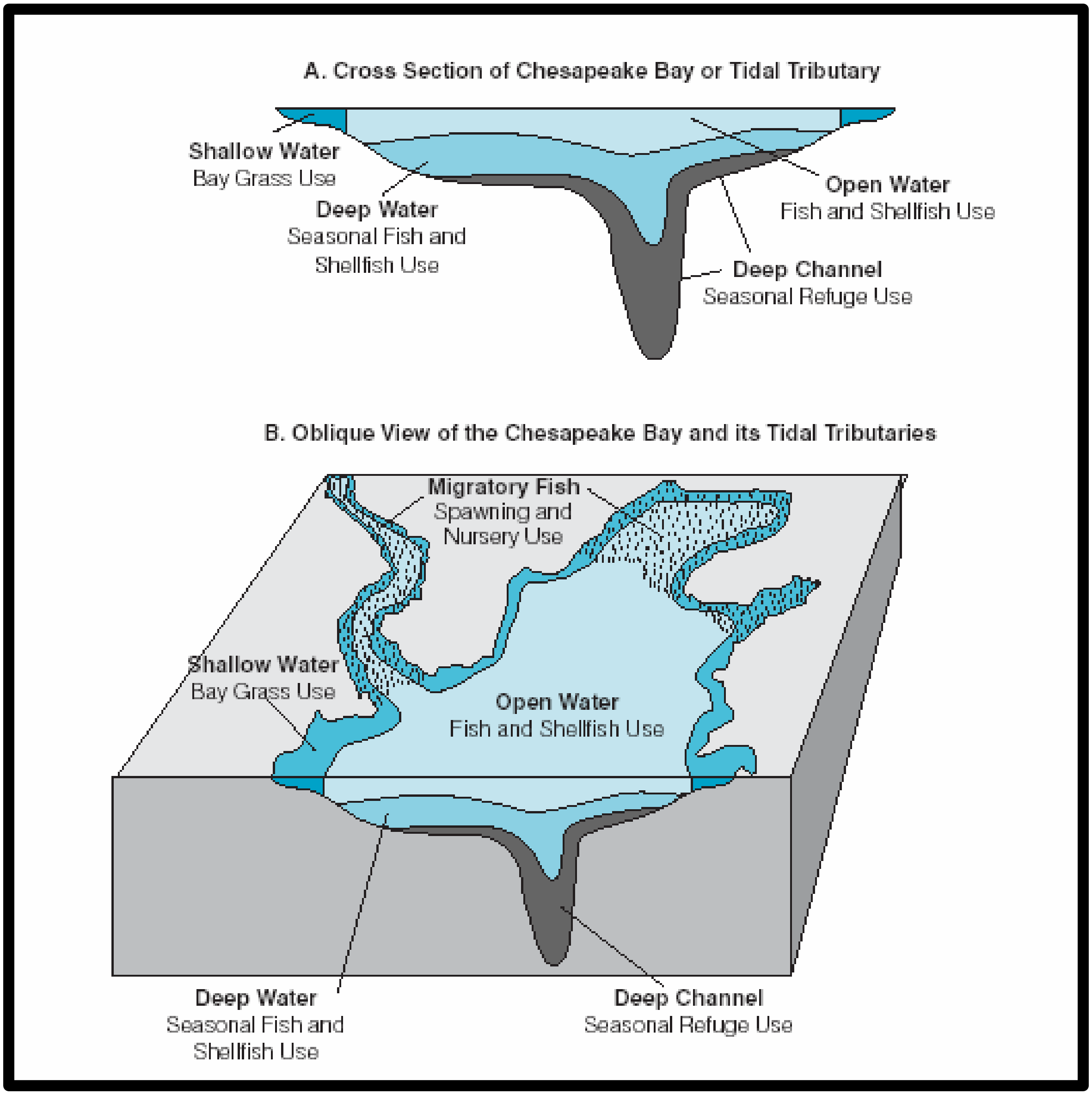


Table III-2. Chesapeake Bay Dissolved Oxygen criteria.

Designated Use	Criteria Concentration/Duration	Protection Provided	Temporal Application
Migratory fish spawning and nursery use	7-day mean $\geq$ 6 mg liter^{-1} (tidal habitats with 0-0.5 ppt salinity)	Survival/growth of larval/juvenile tidal-fresh resident fish.; protective of threatened/endangered species.	February 1 - May 31
	Instantaneous minimum $\geq$ 5 mg liter^{-1}	Survival and growth of larval/juvenile migratory fish; protective of threatened/endangered species.	
	Open-water fish and shellfish designated use criteria apply		June 1 - January 31
Shallow-water bay grass use	Open-water fish and shellfish designated use criteria apply		Year-round
Open-water fish and shellfish use[1]	30-day mean $\geq$ 5.5 mg liter^{-1} (tidal habitats with 0-0.5 ppt salinity)	Growth of tidal-fresh juvenile and adult fish; protective of threatened/endangered species.	Year-round
	30-day mean $\geq$ 5 mg liter^{-1} (tidal habitats with >0.5 ppt salinity)	Growth of larval, juvenile and adult fish and shellfish; protective of threatened/endangered species.	
	7-day mean $\geq$ 4 mg liter^{-1}	Survival of open-water fish larvae.	
	Instantaneous minimum $\geq$ 3.2 mg liter^{-1}	Survival of threatened/endangered sturgeon species.[2]	
Deep-water seasonal fish and shellfish use	30-day mean $\geq$ 3 mg liter^{-1}	Survival and recruitment of bay anchovy eggs and larvae.	June 1 - September 30
	1-day mean $\geq$ 2.3 mg liter^{-1}	Survival of open-water juvenile and adult fish.	
	Instantaneous minimum $\geq$ 1.7 mg liter^{-1}	Survival of bay anchovy eggs and larvae.	
	Open-water fish and shellfish designated-use criteria apply		October 1 - May 31
Deep-channel seasonal refuge use	Instantaneous minimum $\geq$ 1 mg liter^{-1}	Survival of bottom-dwelling worms and clams.	June 1 - September 30
	Open-water fish and shellfish designated use criteria apply		October 1 - May 31

[1] Special criteria for the Mattaponi and Pamunkey rivers are 30 day mean > 4.0 mg/l ;Instantaneous minimum > 3.2 mg/l at temperatures <29°C;Instantaneous minimum > 4.3 mg/l at temperatures > 29°C

[2] At temperatures considered stressful to shortnose sturgeon (>29°C), dissolved oxygen concentrations above an instantaneous minimum of 4.3 mg liter^{-1} will protect survival of this listed sturgeon species.

The newly proposed dissolved oxygen criteria to protect these uses are shown in Table III-2. The proposed methodology for assessing monitoring data against these criteria is very different than has traditionally been used for regulatory criteria. It involves a spatial interpolation of fixed site monitoring results to create a 3-D picture of oxygen conditions in thousands of individual grid cells throughout the Bay. Each individual grid cell is then assessed against the criteria. In this way, the volume of water in attainment is calculated for each data collection cruise and a "spatial" assessment achieved. In order to account for naturally induced fluctuations over seasons and years, the individual spatial assessments of a three-year time period are aggregated, creating a "temporal" viewpoint. The final assessment involves examining the cumulative frequency distribution (CFD) of attainment from the aggregated data. In this way, a combined "space-time" assessment is achieved which allows a much more detailed analysis of water quality conditions.

Figure 6 shows an evaluation of where these criteria are attained based upon an analysis using the CFD approach, utilizing data collected during of the time period of 1984 through 1995.

- Full attainment of the criteria was achieved throughout the **James** river as well as parts of the **Potomac**, **Rappahannock**, and Virginia **Chesapeake Bay**

- Open water use areas of the middle **Potomac**, Lower **Rappahannock**, lower **York**, **Elizabeth** River, and much of Virginia's **Chesapeake Bay** show the lowest non-attainment rates ranging from 1-10%. Deep water use zones of the mainstem **Chesapeake Bay** and lower **Potomac** River also show a non-attainment rate of 1-10%.

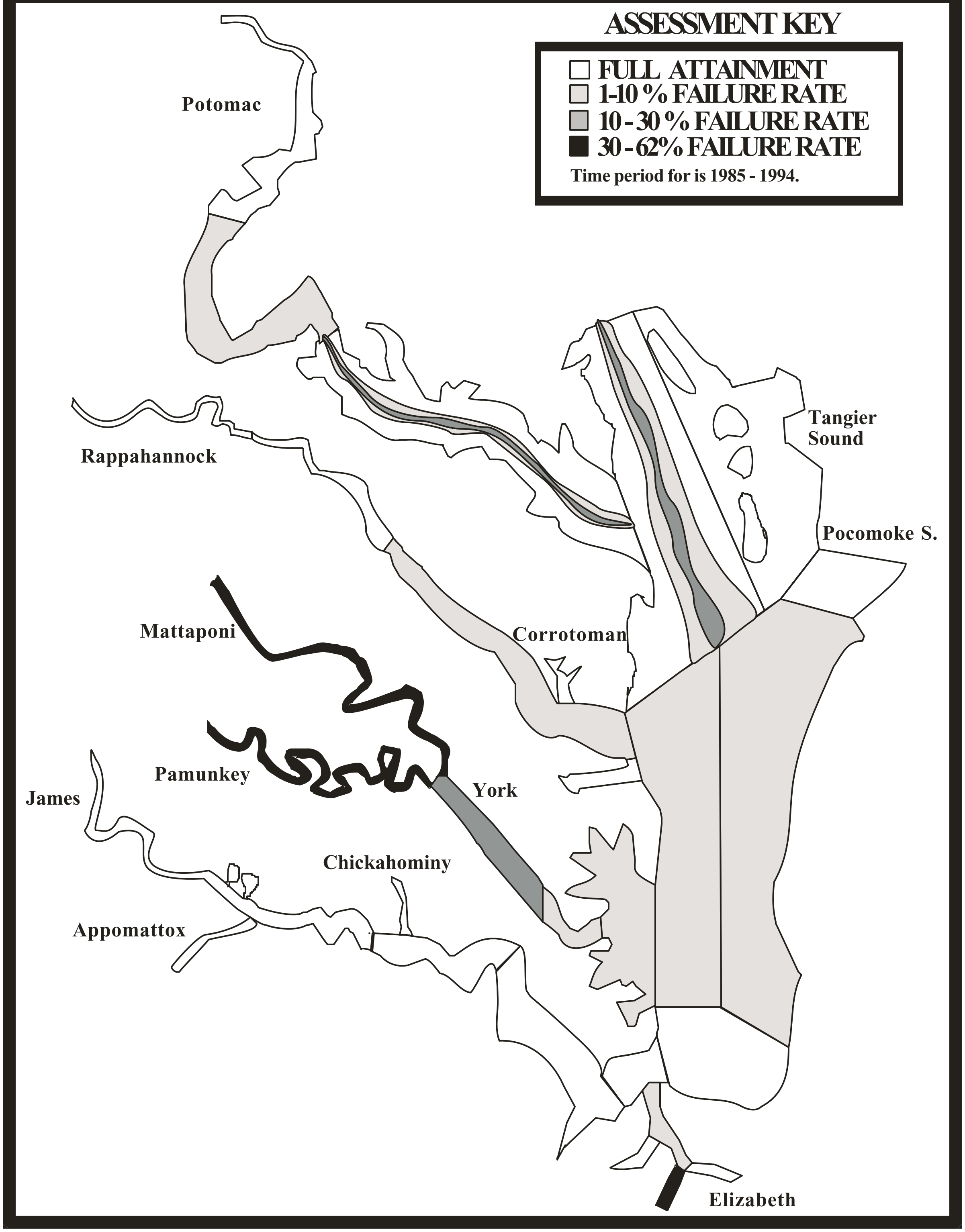
- Higher non-attainment rates (10-30%) are found in the deep channel use zones of the lower **Potomac** and mainstem **Chesapeake Bay** segments.

- Quite high non-attainment rates (30-60%) are observed in the **Mattaponi**, **Pamunkey**, and Southern Branch of the **Elizabeth**.

- Predictive computer modeling suggests that if the nutrient and sediment allocations discussed in section II are met, then all these segments should come into attainment with the new criteria.

There are several caveats to this assessment. First, it is recognized that some portion of the non-attainment found in the **Mattaponi** and **Pamunkey** Rivers is due to natural influence of the extensive fringing wetlands. Therefore these rivers have special criteria which were not used in this assessment. Secondly, this assessment is based on a ten-year data period (1985 – 1995) and is not reflective of current conditions or the proposed three-year data period (2001 – 2003) used to present the status for other parameters in this report. Finally, the complete regulatory assessment methodology (including final criteria numbers and data analysis tools) is still under development. It is expected that these will be finalized during 2005. With these caveats, this demonstrates the new process that will be used in defining a realistic regulatory framework for Chesapeake Bay restoration.

Figure 6) Dissolved Oxygen Criteria Attainment



Water Clarity: Water clarity is a measure of the depth of sunlight penetration through the water. Poor water clarity conditions are inadequate for the growth of rooted aquatic plants (i.e., submerged aquatic vegetation or "SAV"). Poor water clarity can also affect the health of fish populations by reducing their ability to capture food or avoid predators. The major factors that affect water clarity include: 1) concentrations of particulate mineral particles (i.e., sand, silt and clays), 2) concentrations of algae (phytoplankton), 3) concentrations of particulate detritus (small particles of dead algae and/or decaying marsh grasses), and 4) dissolved substances which "color" the water (e.g., brown humic acids generated by plant decay). Which of these factors most influences water clarity varies both seasonally and spatially.

Figure 7 presents the current status and long term trends in water clarity. Status of much of the **Potomac** and all of the **Chesapeake Bay** are only fair or poor. This suggests that poor water clarity is one of the major environmental factors inhibiting the resurgence of SAV growth in **Chesapeake Bay**.

Degrading trends in water clarity were detected in segments located over a wide geographic area and particularly in the Virginia **Chesapeake Bay**. These degrading trends represent a substantial impediment to the recovery of SAV beds within **Chesapeake Bay**. Possible causes of the degrading trends included increased shoreline erosion as a result of waterside development, loss of wetlands, increased abundance of phytoplankton, or a combination of sea level rise and land subsistence.

Water Clarity in relation to new Bay criteria: As discussed previously for dissolved oxygen, there have recently been new criteria for water clarity developed and published by EPA ("Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries (April 2003)". These criteria are expressed as either "percent light through water" or acres of mapped vegetation and are shown in table III-3.

Figure 7a shows an evaluation of where these criteria are attained based upon an analysis using the previously discussed CFD approach on water clarity data collected during of the time period of 1984 through 1995.

- Full attainment of the criteria is evident in the **James** and **York** rivers, upper **Rappahannock**, and parts of the **Virginia Chesapeake Bay**.

- The worst area of non-attainment is in the upper **Potomac** River where there is 73-75% failure rate.

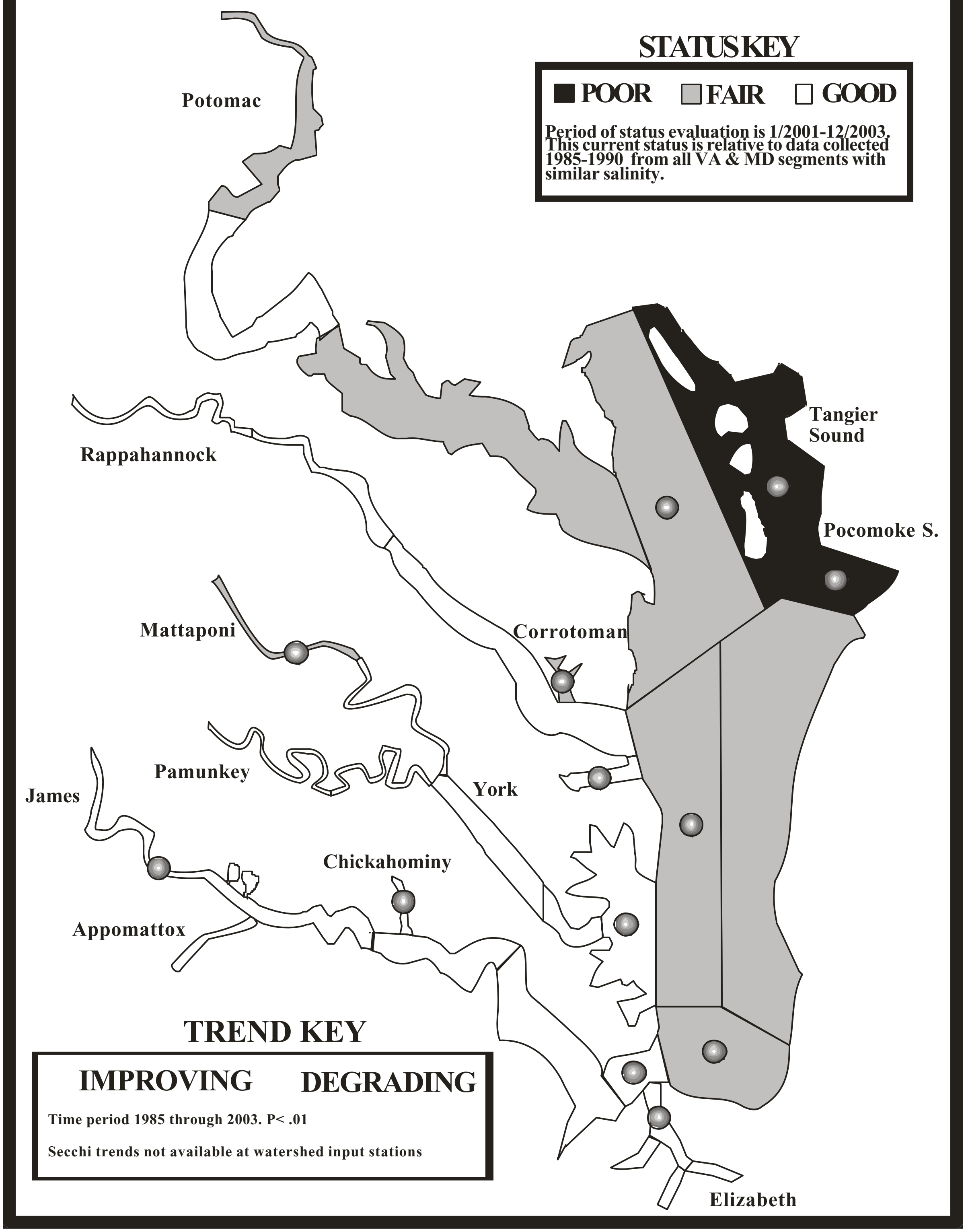
- Lower levels of non-attainment (1-50%) are found in the lower **Potomac**, much of the **Virginia Chesapeake Bay**, lower **Rappahannock**, and **Mobjack** Bay.

There are several caveats to this assessment. First, this assessment is based on a ten-year data period (1985 – 1995) and is not reflective of current conditions or the proposed three-year data period (2001 – 2003) used to present the status for other parameters in this report. Second, the complete regulatory assessment methodology (data analysis tools) is still under development and expected to be finalized during 2005. Third is that missing from this assessment an analysis of where current levels of submerged aquatic plants meet the criteria. Despite these caveats, this presentation demonstrates some of the new process that will be used in defining a realistic regulatory framework for Chesapeake Bay restoration.

Table III-3. Summary of Chesapeake Bay water clarity criteria for application to shallow-water bay grass designated use habitats.

Chesapeake Bay Program Segment	SAV Acres[1]	Water Clarity Criteria (percent light-through-water)[2]	Water Clarity Acres[1]	Temporal Application
CB5MH	7,633	22%	14,514	April 1 - October 31
CB6PH	1,267	22%	3,168	March 1 - November 30
CB7PH	15,107	22%	34,085	March 1 - November 30
CB8PH	11	22%	28	March 1 - November 30
POTTF	2,093	13%	5,233	April 1 - October 31
POTOH	1,503	13%	3,758	April 1 - October 31
POTMH	4,250	22%	10,625	April 1 - October 31
RPPTF	66	13%	165	April 1 - October 31
RPPOH	0	-	0	-
RPPMH	1700	22%	5000	April 1 - October 31
CRRMH	768	22%	1,920	April 1 - October 31
PIAMH	3,479	22%	8,014	April 1 - October 31
MPNTF	85	13%	213	April 1 - October 31
MPNOH	0	-	0	-
PMKTF	187	13%	468	April 1 - October 31
PMKOH	0	-	0	-
YRKMH	239	22%	598	April 1 - October 31
YRKPH	2,793	22%	6,982	March 1 - November 30
MOBPH	15,901	22%	33,990	March 1 - November 30
JMSTF2	200	13%	500	April 1 - October 31
JMSTF1	1000	13%	2500	April 1 - October 31
APPTF	379	13%	948	April 1 - October 31
JMSOH	15	13%	38	April 1 - October 31
CHKOH	535	13%	1,338	April 1 - October 31
JMSMH	200	22%	500	April 1 - October 31
JMSPH	300	22%	750	March 1 - November 30
WBEMH	0	-	0	-
SBEMH	0	-	0	-
EBEMH	0	-	0	-
LAFMH	0	-	0	-
ELIPH	0	-	0	-
LYNPH	107	22%	268	March 1 - November 30
POCOH	0	-	0	-
POCMH	4,066	22%	9,368	April 1 - October 31
TANMH	13,579	22%	22,064	April 1 - October 31

Figure 7) Water Clarity Status and Trends

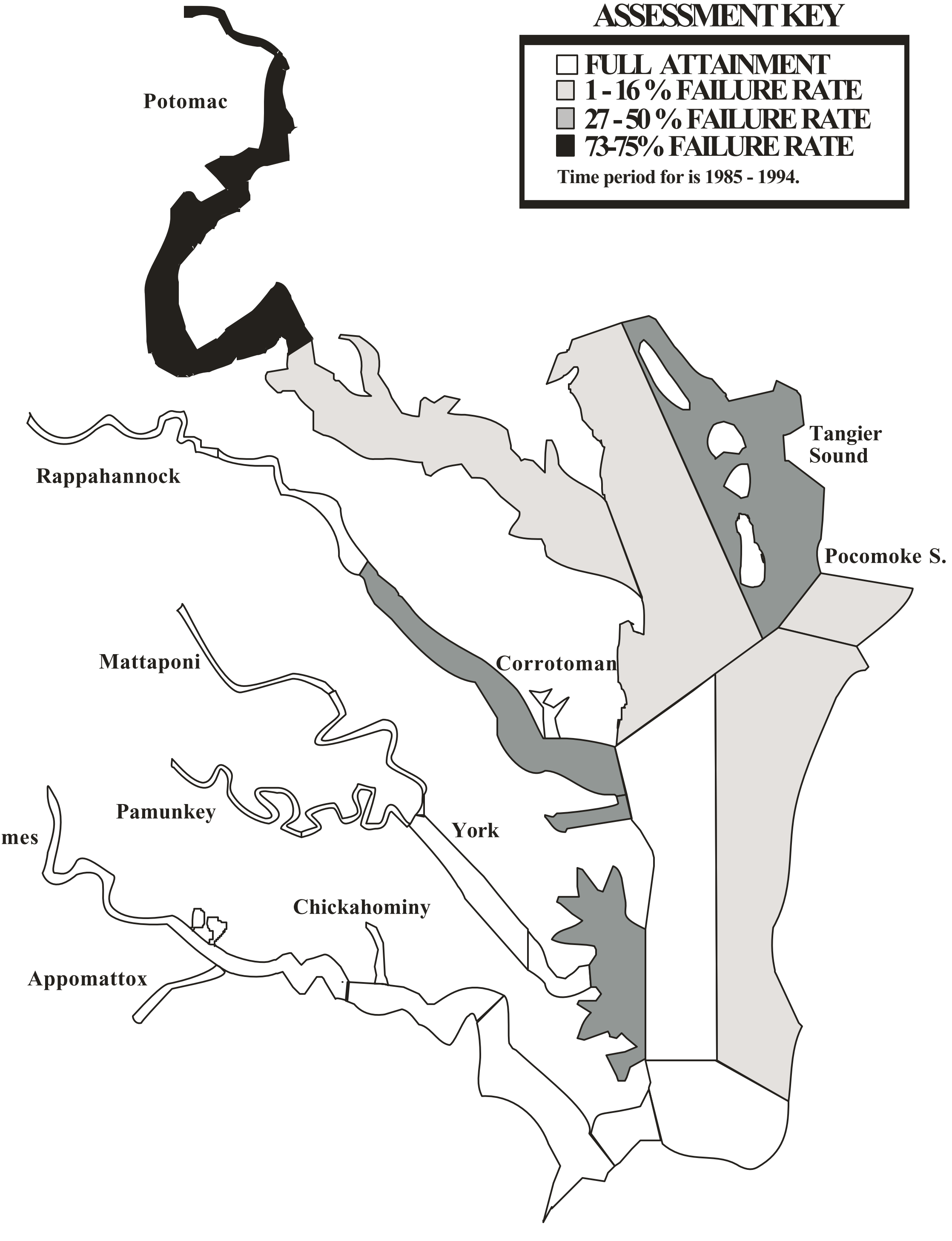


Period of status evaluation is 1/2001-12/2003. This current status is relative to data collected 1985-1990 from all VA & MD segments with similar salinity.

Time period 1985 through 2003. P< .01

Secchi trends not available at watershed input stations

Figure 7a) Water Clarity Criteria Attainment

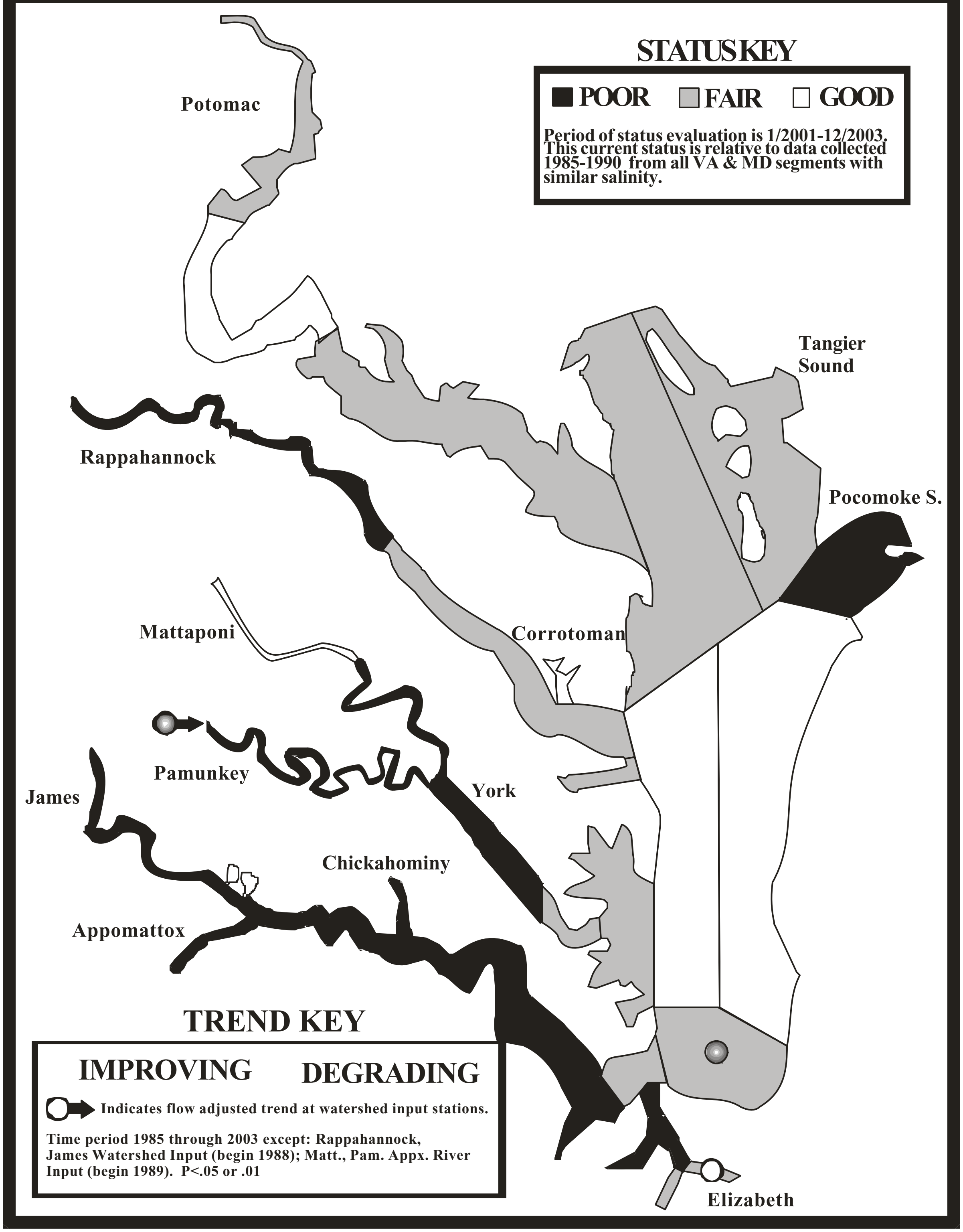


Suspended Solids: this is a measure of particulates in the water column including mineral particles, small living organisms, and detritus which influence water clarity for SAV. Elevated suspended solids can also be detrimental to the survival of oysters and other aquatic animals. Young oysters can be smothered by deposition of material and the diet of filter feeding fish such as menhaden can be negatively affected by high concentrations of suspended solids. In addition, since suspended solids is comprised of organic and mineral particles that contain nitrogen and phosphorus or to which nitrogen and phosphorus compounds are adsorbed, increases in suspended solids can result in an increase of nutrient concentrations.

Figure 8 presents the current status and long term trends in suspended solids concentrations. All of the **major Virginia tributaries** have large areas that are fair or poor. Much of the **Chesapeake Bay** has good relative levels of suspended solids.

Few trends have been observed for suspended sediments. Degrading trends are found at the **Pamunkey** River watershed input station and in the lower **Chesapeake Bay**. The only improving conditions are found in the eastern branch **Elizabeth** River.

Figure 8) Suspended Solids Status and Trends



Water Quality on the Eastern Shore

The Eastern Shore of Virginia is an 80-mile long peninsula that has approximately half of its 696 square miles draining into the Chesapeake Bay via a complex system of tidal creeks guts and inlets. The tidal creeks of the Eastern Shore are often shallow and tidally well mixed and tend to be deepest and widest at the mouth and shallow and narrow in their freshwater portions. (Figure 9).

Figure 9. Virginia's Eastern Shore Peninsula.

Image downloaded from www.virginiaplaces.com website.

Six creeks and tidal embayments on Virginia's Eastern Shore monitored during 2001-2003 had stations located in areas considered historically important habitats for submerged aquatic vegetation (SAV): Hungars Creek, Kings Creek, Nassawadox Creek, Occohannock Creek, Onancock Creek and The Gulf. Half of the monitored sites (Hungars Creek, Kings Creek and The Gulf) had a single station located in an SAV habitat (Table III-4) and the other half (Cape Charles Harbor, Occohannock Creek and Onancock Creek) had two stations located in historically important SAV habitats. Additionally during 2001 and 2002, the Virginia Institute of Marine Science (VIMS) conducted a study in cooperation with the Alliance for the Chesapeake Bay (ACB) in conjunction with Virginia's Eastern Shore Watersheds Network to collect nutrient and water clarity data from six sites along the Eastern Shore (Table III-4). The VIMS study results were presented in detail in the 2002 Report of the Secretary of Natural Resources entitled "2002 Annual Report on the Environmental Conditions of Virginia's Chesapeake Bay and Tributaries, Implementation of the Chesapeake Bay Agreement, and Implementation of Tributary Strategies for the Reduction of Nutrients and Sediments" (available at http://www.deq.virginia.gov/bay/wqifdown.html) and the final report prepared for DEQ by VIMS is included in Appendix B of the Chesapeake Bay Nutrient and Sediment Reduction Tributary Strategy for the Eastern Shore (available in draft form at http://www.snr.state.va.us/Initiatives/TributaryStrategies/index.cfm).

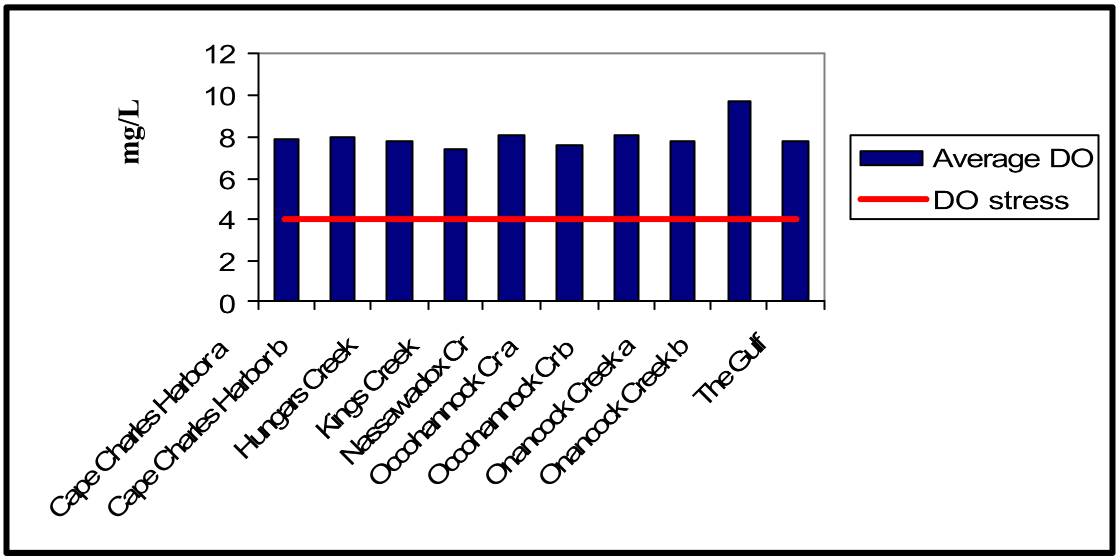
Table III-4. Station locations for DEQ stations monitored 2001-2003 and VIMS station locations monitored 2001-2002 in historically important Chesapeake Bay SAV habitats.

Stream Name	Reference Name	Storet Station Name	Approximate distance from mouth of creek	Monitoring Agency
Cape Charles Harbor	Cape Charles Harbor a	7-CCH000.00	0	DEQ
Cape Charles Harbor	Cape Charles Harbor b	7-CCH000.43	0.43	DEQ
Cherrystone Inlet	C1		1.01	VIMS
Cherrystone Inlet	C2		2.67	VIMS
Cherrystone Inlet	C3		3.17	VIMS
Chesconessex Creek	CC1		3.46	VIMS
Chesconessex Creek	CS3		3.73	VIMS (2001 only)
Hungar's Creek	Hungar's Creek	7-HUG001.24	1.24	DEQ
Hungar's Creek	H1		0.98	VIMS
Hungar's Creek	H2		1.71	VIMS
Hungar's Creek	H3		2.75	VIMS
Kings Creek	Kings Creek	7-KNS000.40	0.4	DEQ
Nassawadox Creek	Nassawadox Cr	7-NSS001.62	1.62	DEQ
Occohannock Creek	OC2		3.89	VIMS
Occohannock Creek	OC3		5.45	VIMS (2001 only)
Occohannock Creek	Occohannock Cr a	7-OCH001.60	1.6	DEQ
Occohannock Creek	Occohannock Cr b	7-OCH003.82	3.82	DEQ
Old Plantation Creek	OP1		0.37	VIMS
Old Plantation Creek	OP2		1.43	VIMS
Old Plantation Creek	OP3		2.49	VIMS
Onancock Creek	ON3		4.73	VIMS
Onancock Creek	Onancock Creek a	7-OCN001.92	1.92	DEQ
Onancock Creek	Onancock Creek b	7-OCN003.28	3.28	DEQ

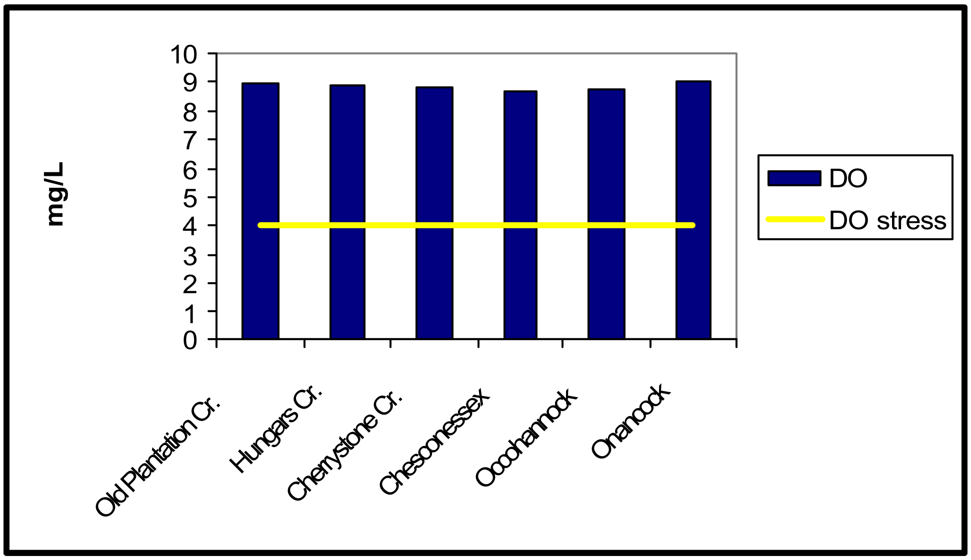
Dissolved Oxygen: Average dissolved oxygen concentrations were similar at all stations located in SAV habitats and well above the water quality criteria of 4 mg/L at all stations during periods considered critical to living resources (Figure 10).

Figure 10) Dissolved Oxygen Concentrations 2001-2003

a. Average Dissolved Oxygen Concentrations for DEQ sites (May-March and September-November 2001-2003).



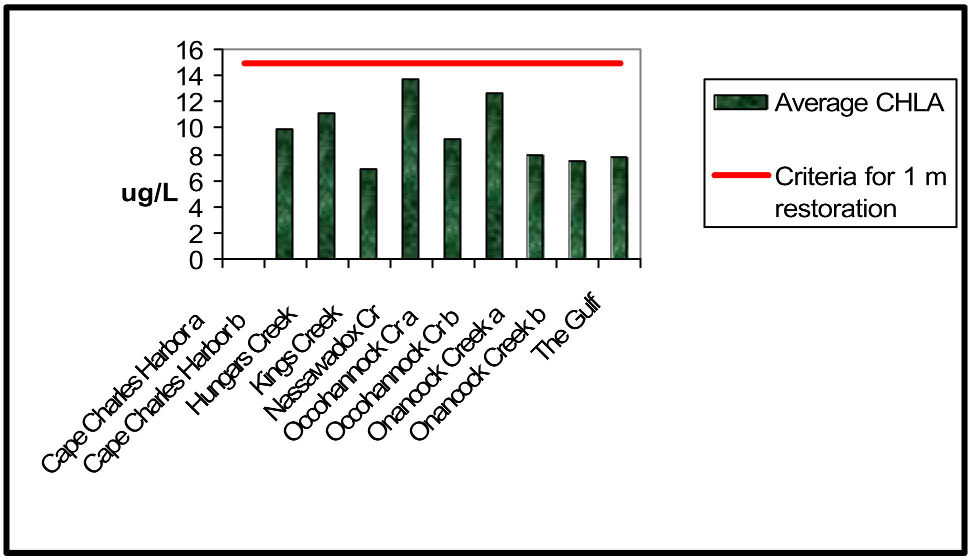
b. Average Dissolved Oxygen Concentrations for VIMS sites (May-March and September-November 2001-2002).



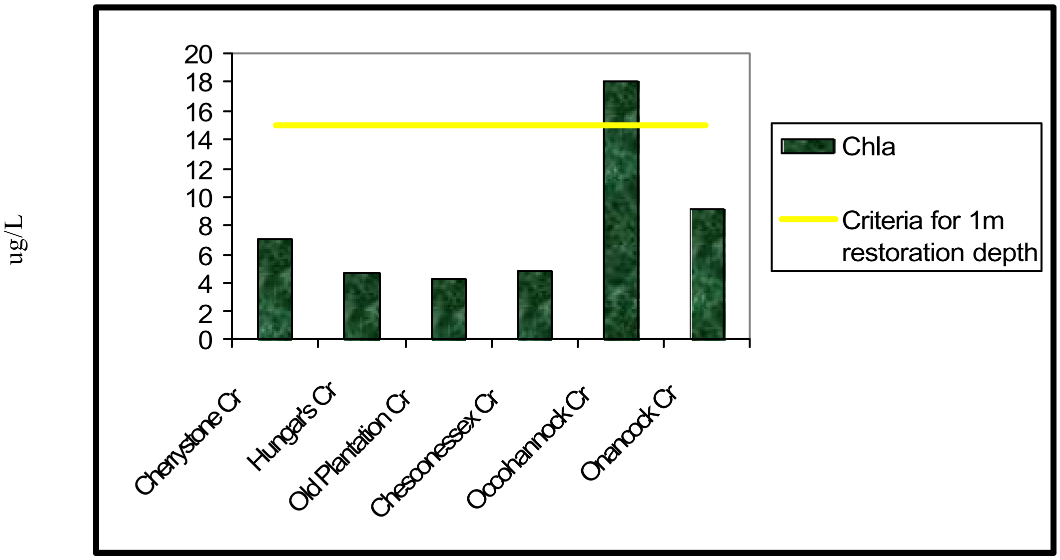
<u>*Chlorophyll:*</u> The annual average target for chlorophyll *a* for 1-meter restoration of SAV was also met on all creeks located in historically important SAV habitats during 2001-2003, with the exception of the Occohannock creek site monitored by VIMS in 2001(Figure 11). The Occohannock creek site was sampled twice by VIMS during the 2001 SAV growth season. One sample concentration met the 1 meter chlorophyll *a* criteria and the other did not.

Figure 11) Chlorophyll Concentrations 2001-2003

a. Average Chlorophyll a concentrations at DEQ monitored sites (May-March and September-November 2001-2003).



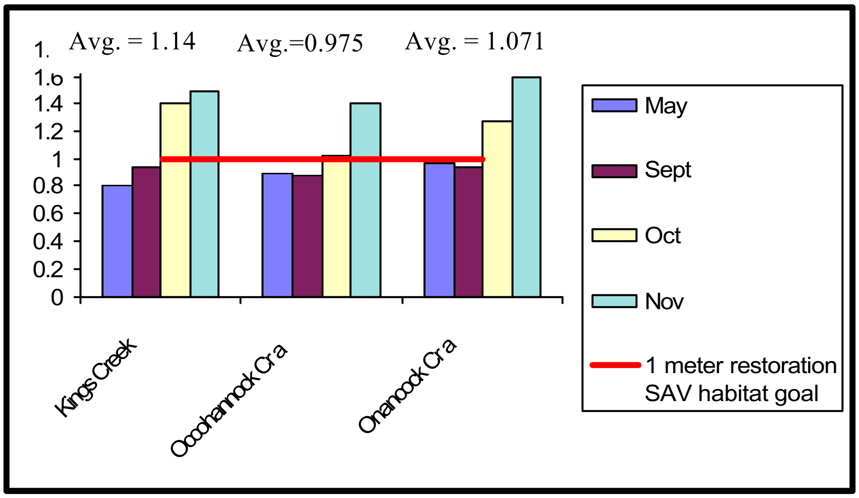
b. Average Chlorophyll a concentrations at VIMS monitored sites (May-March and September-November 2001-2003).



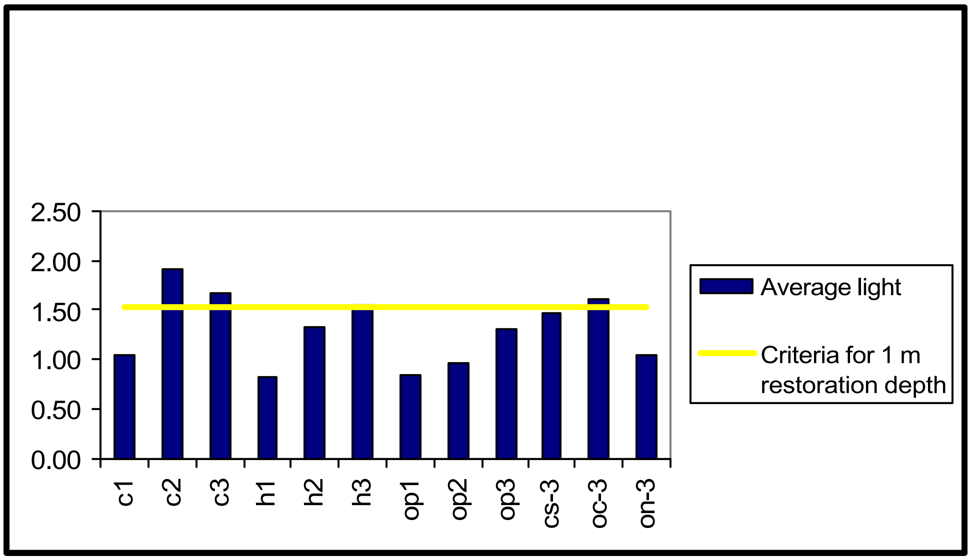
Water Clarity: Water clarity was measured by secchi depth at the DEQ stations and by light attenuation at the VIMS sites. Both methods demonstrated variability in water clarity depending upon site location and sampling date (Figure 12). Only three of the DEQ stations monitored in the

Figure 12) Eastern Shore Water Clarity 2001-2003

a. Water clarity for DEQ monitored sites as determined by Secchi depth (March - May and September - November).



b. Water clarity for VIMS monitored sites as determined by light attenuation coefficient KD. Average concentrations during SAV growth season (May-March and September – November) on the Chesconessex Creek (cs3), Occohannock Creek (oc3), Onancock Creek (on3), Cherrystone Inlet (c1, c2, c3), Hungar's Creek (h1, h2, h3) and Old Plantation Creek (op1, op2, op3). Stations with multiple sites were sampled at the mouth (c1, h1 and op1), midstream (c2, h2 and op2) and upstream (c3, h3 and op3). Water clarity criteria as light attenuation coefficient KD (Kollar and S. Bieber. 1992. Submerged Aquatic Vegetation Habitat Requirements and Restoration Targets: A Technical Synthesis. Chesapeake Bay Program, Annapolis, Maryland).



SAV habitat areas had water clarity data associated with them. Average secchi depth during the SAV growth season for Occohannock Creek met the SAV criteria for 1-meter restoration while Kings Creek and Onancock Creeks did not. However, water clarity did not meet the 1-meter restoration criteria on the Occohannock Creek at least two of the months sampled during the SAV growth season. Sites monitored by VIMS also demonstrated a great deal of variability in water clarity with most sites meeting the 1-meter restoration criteria. In general, creeks with stations monitored at the mouth, midstream and upstream tended to demonstrate progressively decreasing water clarity at the mid and upstream sites. In contrast to DEQ data, average water clarity as measured by VIMS for the Onancock creek met the 1-meter criteria and the Occohannock creek did not.

Suspended Solids: Suspended solids concentrations can vary greatly depending on the levels of wind mixing of inorganic mineral particles, planktonic organisms and detritus suspended in the water column. This variation often results in observed differences between sites located at the mouths of tidal creeks (DEQ "a" sites such as Cape Charles Harbor a) and a site located in a more sheltered area upstream (DEQ "b" sites such as Cape Charles Harbor b). During the 2001-2003 monitoring period, approximately half of the tidal creeks monitored by DEQ in historically important SAV areas did not meet the 1-meter suspended solids criteria for SAV restoration (Figure 13). In two of the tidal creeks that did not meet the criteria for suspended solids, samples were collected at a downstream site as well as an upstream site. In both instances the more protected upstream sites had lower concentrations of suspended solids than the downstream sites. This contrasts the findings of the 2001-2002 results reported by VIMS for total suspended solids where average concentrations of suspended sediment failed to meet the 1-meter restoration criteria at all sites. As with water clarity, creeks monitored at the mouth, midstream and upstream often demonstrated progressively increasing concentrations of suspended solids at the mid- and upstream sites (Figure 14) (*Water Quality Monitoring for the Eastern Shore Tributary Strategy Program*, Gretchen Arnold and Mark Luckenbach, VIMS, 2002).

Figure 13) Total Suspended Solid Concentrations for DEQ monitored sites on the Eastern Shore 2001-2003 (March - May and September - November).

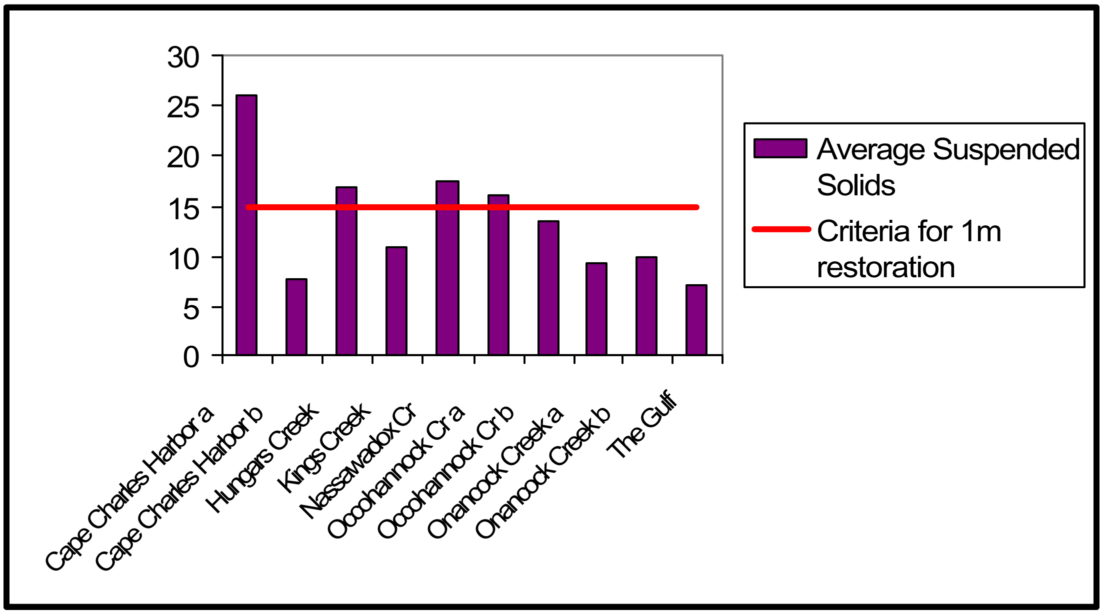
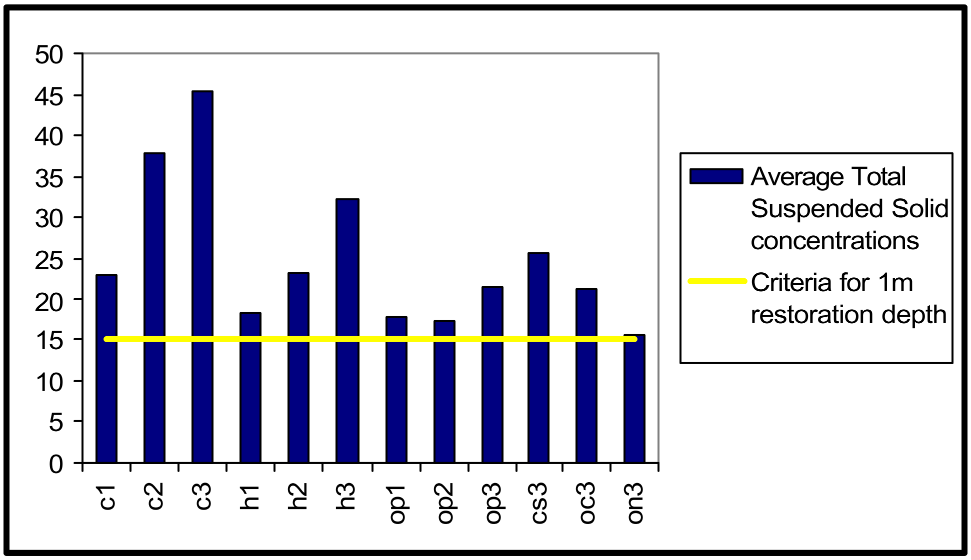


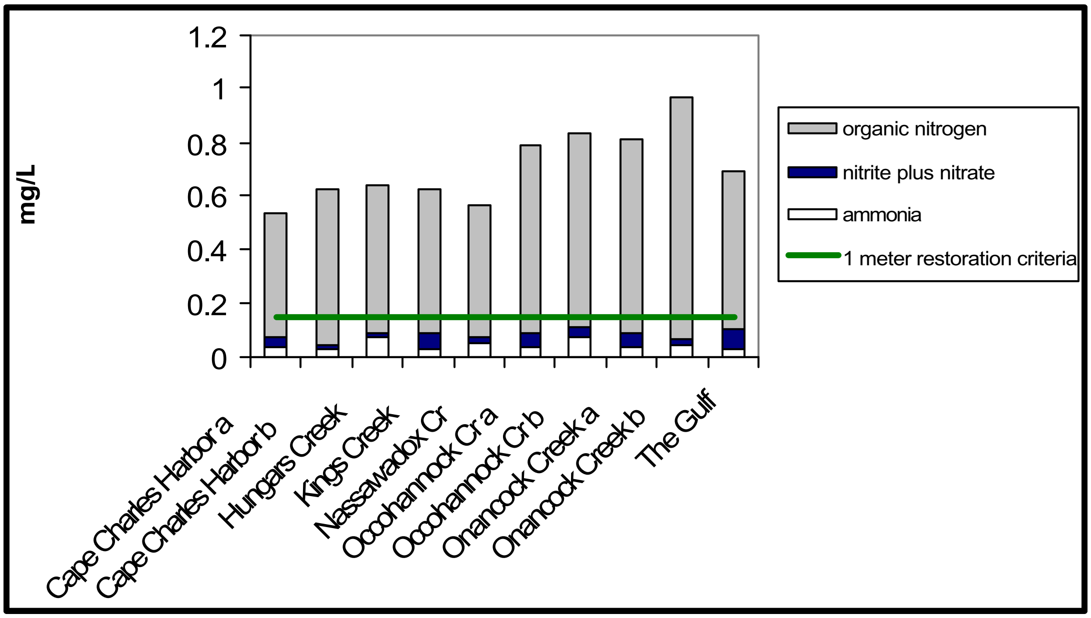
Figure 14. Suspended sediment concentrations for VIMS monitored sites.
Average concentrations during SAV growth season (May-March and September – November) on the Chesconessex Creek (cs3), Occohannock Creek (oc3), Onancock Creek (on3), Cherrystone Inlet (c1, c2, c3), Hungar's Creek (h1, h2, h3) and Old Plantation Creek (op1, op2, op3). Stations with multiple sites were sampled at the mouth (c1, h1 and op1), midstream (c2, h2 and op2) and upstream (c3, h3 and op3). Water clarity criteria as light attenuation coefficient KD (Kollar and S. Bieber. 1992. Submerged Aquatic Vegetation Habitat Requirements and Restoration Targets: A Technical Synthesis. Chesapeake Bay Program, Annapolis, Maryland).



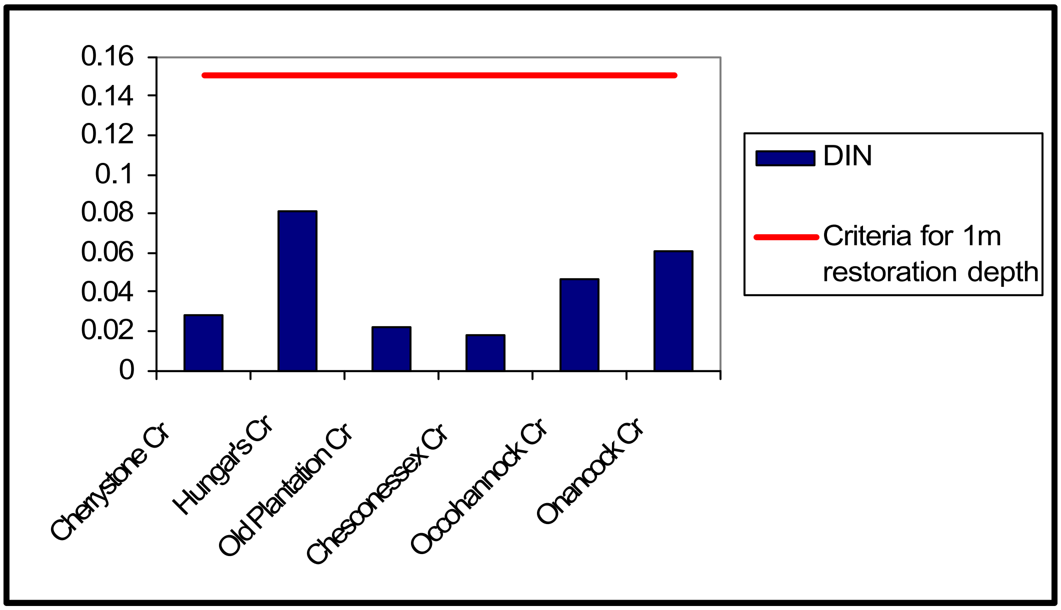
Nutrients: Figure 15 depicts total nitrogen and its components for the SAV habitat stations monitored by DEQ and dissolved inorganic nitrogen (DIN) concentrations at VIMS sites. At DEQ sites the organic nitrogen was the largest component of the total nitrogen at all sites with highest nitrogen concentrations occurring in the upstream sites. Average concentrations of total inorganic nitrogen ranged from 0.04 mg/L to 0.1 mg/L and thus met the 1-meter restoration criteria of 0.15 mg/L. Average DIN concentrations for VIMS sites ranged from 0.01 to 0.08 mg/L, also meeting the 1-meter restoration criteria. Both agencies also found greater levels of nitrogen in the upstream sites as would be expected since 72 percent of the total load of nitrogen is contributed by agricultural land uses (*Chesapeake Bay Nutrient and Sediment Reduction Tributary Strategy for the Eastern Shore*, Commonwealth of Virginia, 2004; draft for public comment).

Figure 15. Nitrogen Concentrations 2001-2003 (March – May and September – November) in sites monitored in SAV habitat areas.

a. Total Nitrogen Concentrations for DEQ monitored sites.



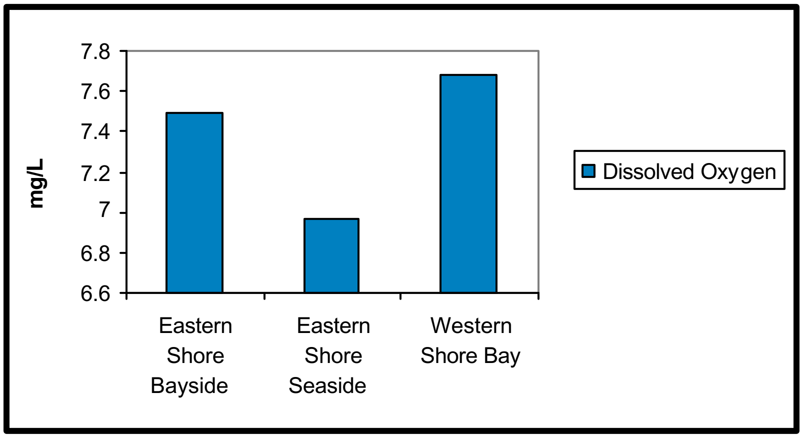
b. Dissolved Inorganic Nitrogen results for VIMS monitored sites.



Comparing Bayside and Seaside Sites: Between 2001 and 2003 DEQ monitored 78 sites on 57 creeks of the Eastern Shore as part of its long-term ambient water quality monitoring program and special studies. Thirty-four of those sites are located in tidal creeks draining into the Chesapeake Bay with the remaining 44 sites located in tidal creeks and embayments draining into the Atlantic Ocean.

Figure 16 contrasts the average dissolved oxygen concentrations for the Eastern Shore Chesapeake Bay coastal stations (Eastern Shore Bayside), Eastern Shore Atlantic coastal stations (Eastern Shore Seaside) and stations in the Western shore creeks of the Chesapeake Bay (Western Shore Bay). Average concentrations were well above levels considered stressful to aquatic life in each station grouping. Concentrations were highest in Western Shore Bay stations and lowest in the Eastern Shore Seaside stations where low dissolved oxygen concentrations most likely occur due to the decomposition of organic matter produced in the very extensive marsh wetlands there.

Figure 16) 2001-2003 Dissolved Oxygen Concentrations.



The average concentration of suspended solids was highest in the Seaside locations and lower in the Eastern Shore Bayside and the Western Shore Bay groupings (Figure 17). These high suspended solids levels in the seaside stations are likely due to natural continual resuspension of materials from the extensive marsh surfaces and shallow water lagoons through a combination of tidal forces and wind.

Figure 17) 2001-2003 Suspended Solids

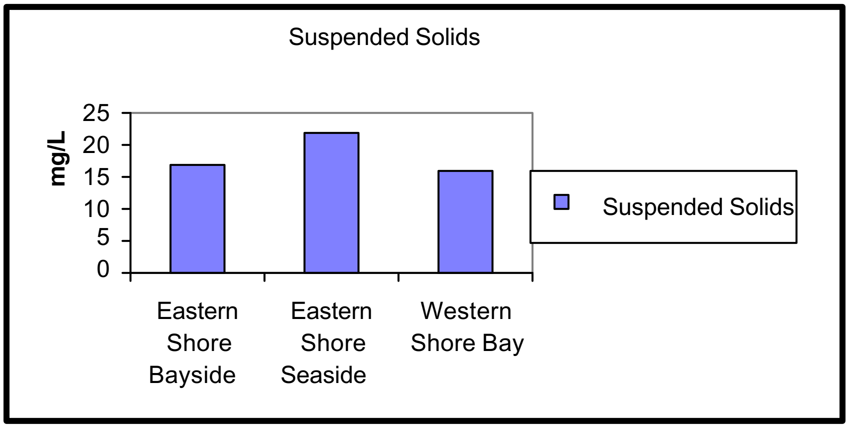
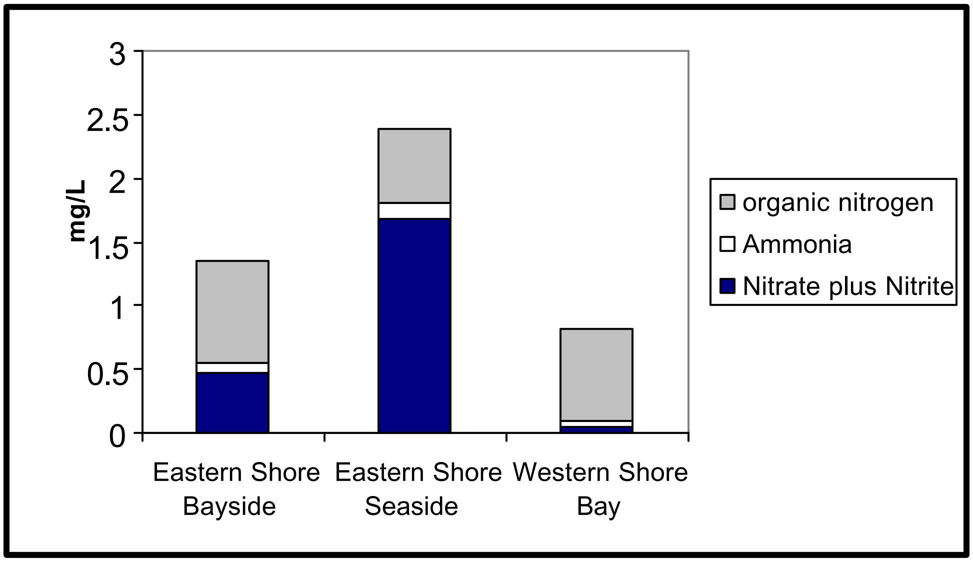


Figure 18a contrasts the average nitrogen concentrations for the Eastern Shore Bayside, Eastern Shore Seaside and Western Shore Bay stations. Excluding the point-source dominated Sandy Bottom Bridge Creek (bayside) and Parkers Creek (seaside), average total nitrogen concentrations of the Eastern Shore bayside and seaside sites were 2-3 times higher than concentrations in Western Shore Bay. Inorganic nitrogen (nitrate plus nitrite) accounted for approximately 68% of the total nitrogen in the Eastern shore bayside sites, 72% of the total nitrogen at the Eastern Shore seaside sites and only 6% of the total nitrogen in the Western shore sites. A likely source of this high percentage of inorganic nitrogen at Eastern Shore stations is runoff and groundwater contamination from agricultural activities since the Eastern Shore is largely comprised of agricultural and forested lands.

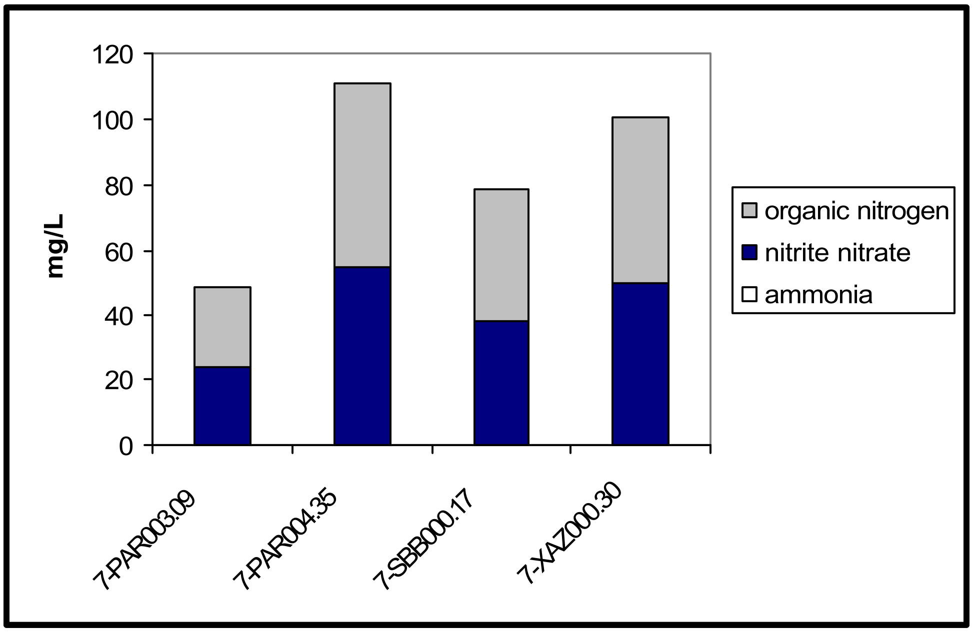
Bayside and Seaside sites during the 2001-2003 SAV growth periods had average inorganic nitrogen levels (nitrate plus nitrite and ammonia) well above the 0.07 mg/L limiting resource concentration level. However on the Western Shore Bay the average total inorganic nitrogen level was 0.08 mg/L and as such the dissolved inorganic nitrogen levels may not have exceeded the 0.07 mg/L required for maximum phytoplankton growth rates. The Virginia Long Term Ecological Program found inorganic nutrient concentrations were significantly higher in the seaside barrier-island lagoons than those in Chesapeake Bay (Shugart, H.H. and L.K. Blum, Annual Progress Report VCR/LTER. May 1991. Department of Environmental Sciences Clark Hall University of Virginia Charlottesville, Virginia 22903). Bacterial abundance, activity, and growth rates were also found to be much lower in the barrier-island lagoon system indicating nutrient cycles and controls on the cycles may be very different in the lagoon system as compared to Chesapeake Bay.

Figure 18) 2001-2003 Total Nitrogen Concentrations.

a. Average concentrations for 2001- 2003 indicate highest concentrations occurred in seaside creeks and embayments.



b. 2001-2003 Average Total Nitrogen concentrations for Sandy Bottom Bridge Creek (7-SBB000.17 and 7-XAZ000.30) and Parkers Creek (7-PAR003.09 and 7-PAR004.35). Both creeks have permitted point source discharges resulting in very high nitrogen concentrations.

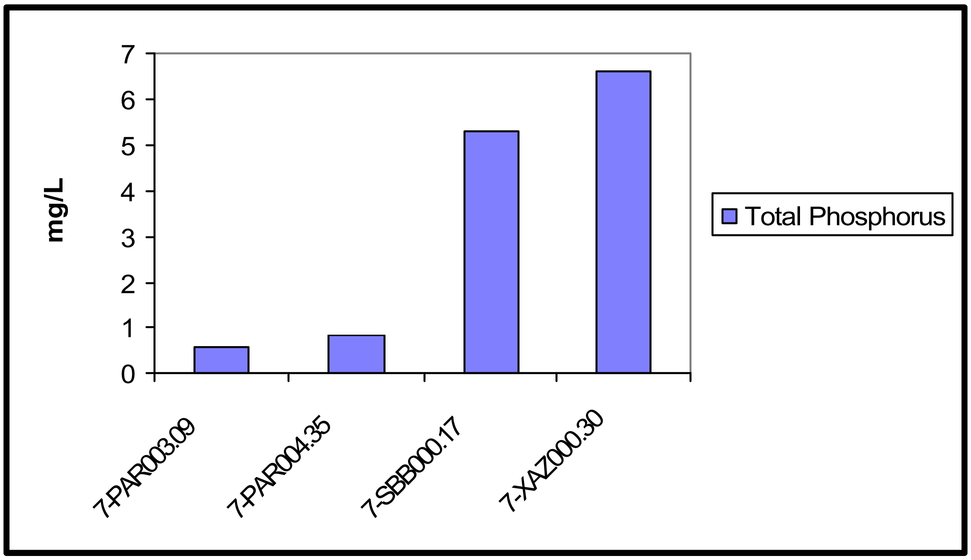


Inorganic nitrogen concentrations were unusually high in Sandy Bottom Bridge Creek and Parkers Creek, accounting for approximately 95% of average total nitrogen concentrations (Figure18b) with total nitrogen concentrations in the two creeks during 2001-2003 approximately 20 times higher than the average concentrations for the remaining stations in bayside and seaside creek groups.

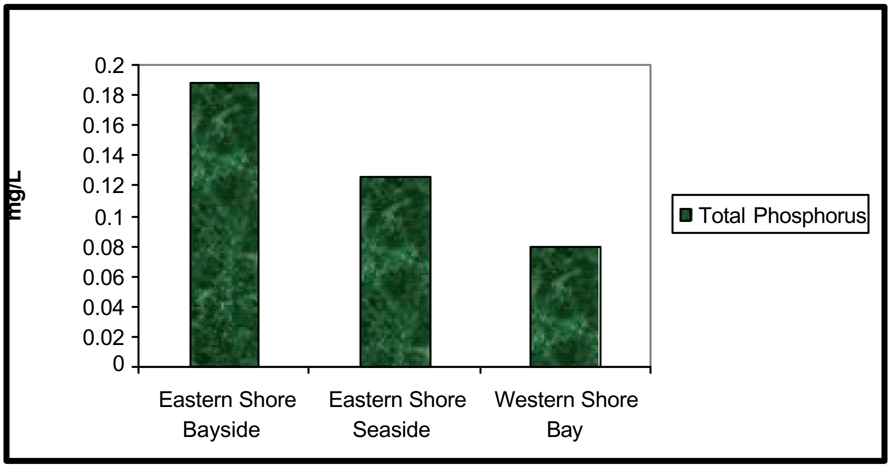
As with total nitrogen, phosphorus concentrations in Eastern Shore bayside tributaries and Eastern Shore seaside tributaries are greater than those found in the Western Shore Bay and are probably a result of agricultural activities (Figure 19a). In 1996 Agricultural crops were reported

Figure19) 2002 Total Phosphorus Concentrations.

a. Total Phosphorus concentrations in Eastern Shore Bayside tributaries, Eastern Shore Seaside tributaries and Western Bay Creeks excluding Sandy Bottom Branch and Parkers Creek.



b. Total Phosphorus concentrations in Sandy Bottom Branch (7-SBB000.17, 7-XAZ000.30) and Parkers Creek (7-PAR003.09 and 7-PAR004.35).

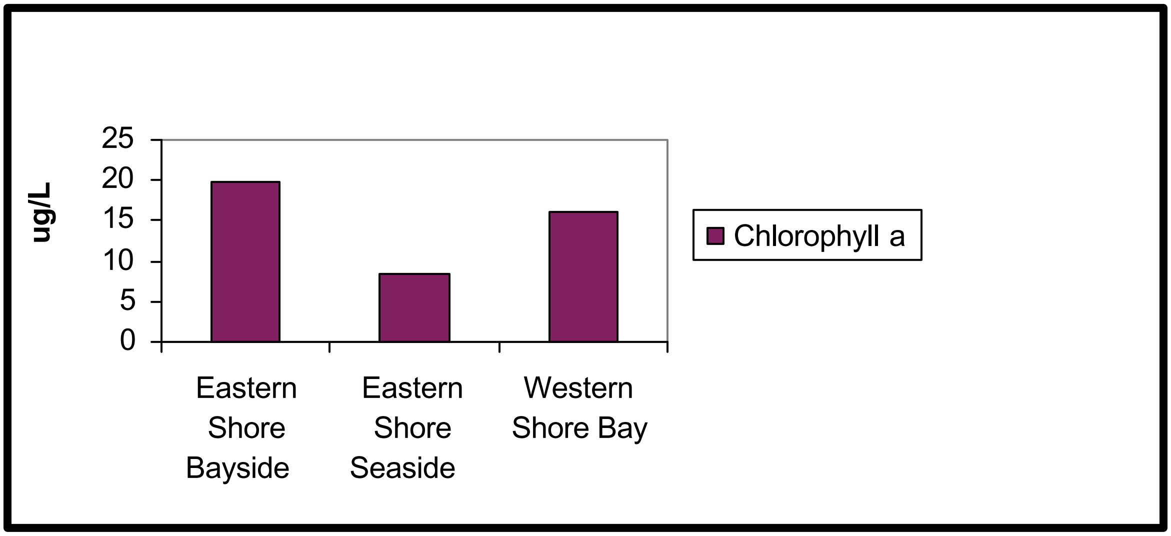


to contribute 65% of the phosphorus loads on the Eastern shore with a 33% increase having occurred between 1985 and 1996 due to increased poultry operations within the watershed.

Also as with nitrogen concentrations, Sandy Bottom Branch Creek, an un-named tributary to Sandy Bottom Branch Creek and two stations on Parkers Creek had unusually high levels of total phosphorus (Figure 19b). These creeks have been listed on the 305(d) Impaired Waters List as impaired for exceeding the nutrient screening value for total phosphorus.

Chlorophyll concentrations for the Eastern Shore Bayside tributaries, Eastern Shore Seaside tributaries and Western Shore Bay are depicted in Figure 20. Chlorophyll *a* concentrations were highest in the Bayside tributaries and lowest in the Seaside tributaries. Both the Eastern Shore Bayside and the Western Shore Bay sites have less suspended solid concentrations than in the Eastern Shore seaside and thus better water clarity which may allow for better phytoplankton growth. Higher concentrations also probably occur in the Eastern Shore Bayside due to the high concentrations of inorganic nutrients readily available for phytoplankton uptake. Studies conducted by the Virginia Coastal Reserve Long Term Ecological Research (LTER) have suggested primary productivity in the barrier-island lagoon system is light limited due to water-column sediment loading rather than nutrient limited (Shugart, H.H. and L.K. Blum, Annual Progress Report VCR/LTER. May 1991. Department of Environmental Sciences Clark Hall University of Virginia Charlottesville, Virginia 22903).

Figure 20) 2002 Chlorophyll a concentrations.



Appendix A: Nutrient Discharge Estimates for Virginia's Significant Point Source Facilities

Table A-1: POTOMAC RIVER BASIN
2003 POINT SOURCE NITROGEN DISCHARGE INVENTORY

LOCATION	FACILITY	2003 TN LOAD DISCH. (LBS/YR)	1985 TN LOAD DISCH. (LBS/YR)	% CHANGE FROM 1985
Waynesboro	DuPont-Waynesboro	25,180	299,630	-92%
Shenandoah	George's Chicken LLC	36,420	147,310	-75%
Prince William	Dale Serv. Corp. #1	35,000	91,320	-62%
Alexandria	Alexandria STP	936,940	1,994,010	-53%
Fairfax	Noman Cole STP	1,061,900	2,225,840	-52%
Prince William	PWCSA-Mooney STP	300,510	609,160	-51%
Prince William	Quantico-Mainside STP	41,290	82,540	-50%
Arlington	Arlington STP	838,550	1,641,280	-49%
Staunton	Staunton-Middle River STP	84,280	162,810	-48%
Rockingham	Merck-Elkton	125,950	233,880	-46%
Frederick	FWSA-Opequon STP	134,800	226,560	-41%
Warren	Front Royal STP	76,510	112,140	-32%
Waynesboro	Waynesboro STP	132,220	190,930	-31%
Shenandoah	Strasburg STP	30,450	42,120	-28%
Rockingham	HRRSA-North River STP	279,740	367,160	-24%
Augusta	ACSA-Stuarts Draft STP	25,620	28,460	-10%
Augusta	Weyers Cave STP	27,650	28,720	-4%
Rockingham	Pilgrims Pride-Hinton	42,190	42,970	-2%
Loudoun	Leesburg STP	71,850	71,730	0%
Loudoun	Purcellville STP	15,680	15,370	2%
DC	Blue Plains - VA Portion	840,850	814,170	3%
Prince William	Dale Serv. Corp. #8	39,980	38,360	4%
King George	King George-Dahlgren STP	6,110	5,690	7%
Westmoreland	Colonial Beach STP	28,980	22,770	27%
Stafford	Aquia STP	95,480	64,890	47%
Rockingham	SIL Clean Water STP	110,370	72,420	52%
Augusta	ACSA-Fishersville STP	70,450	44,400	59%
Shenandoah	Woodstock STP	50,650	26,760	89%
Shenandoah	New Market STP	32,680	15,140	116%
Fairfax	Upper Occoquan S.A.	1,446,560	597,530	142%
Shenandoah	Stoney Creek San. Dist. STP	36,870	14,690	151%
Loudoun	Round Hill STP	11,510	3,420	237%
Page	Luray STP	22,270	3,380	559%
Clarke	Berryville STP	31,600	NA	NA
Rockingham	Coors	32,790	NA	NA
Rockingham	Massanutten PSA STP	31,410	NA	NA
Frederick	Parkins Mill STP	66,260	NA	NA
King George	USNSWC-Dahlgren STP	6,900	NA	NA
Fauquier	Vint Hill STP	6,010	NA	NA
	Basin Total =	**7,290,460**	**10,868,740**	**-33%**

Table A-2: POTOMAC RIVER BASIN
2003 POINT SOURCE PHOSPHORUS DISCHARGE INVENTORY

LOCATION	FACILITY	2003 TP LOAD DISCH. (LBS/YR)	1985 TP LOAD DISCH. (LBS/YR)	% CHANGE FROM 1985
Waynesboro	DuPont-Waynesboro	500	57,200	-99%
Frederick	FWSA-Opequon STP	5,510	77,540	-93%
Loudoun	Purcellville STP	400	5,260	-92%
Arlington	Arlington STP	4,760	46,890	-90%
Waynesboro	Waynesboro STP	6,850	48,320	-86%
Rockingham	HRRSA-North River STP	24,800	125,660	-80%
Fairfax	Noman Cole STP	7,090	30,090	-76%
Warren	Front Royal STP	9,590	38,380	-75%
Shenandoah	George's Chicken LLC	5,690	19,090	-70%
Staunton	Staunton-Middle River STP	17,070	55,720	-69%
King George	King George-Dahlgren STP	650	1,950	-67%
Prince William	Quantico-Mainside STP	330	880	-63%
Augusta	Weyers Cave STP	1,460	3,020	-52%
Loudoun	Leesburg STP	13,480	25,320	-47%
Augusta	ACSA-Stuarts Draft STP	6,510	9,740	-33%
Shenandoah	Strasburg STP	10,600	14,420	-26%
Shenandoah	Woodstock STP	6,770	9,160	-26%
Westmoreland	Colonial Beach STP	6,780	7,790	-13%
Augusta	ACSA-Fishersville STP	14,260	15,200	-6%
Shenandoah	Stoney Creek San. Dist. STP	4,930	5,030	-2%
Prince William	Dale Serv. Corp. #1	1,080	1,100	-2%
Shenandoah	New Market STP	5,840	5,180	13%
Prince William	PWCSA-Mooney STP	4,370	3,690	18%
Prince William	Dale Serv. Corp. #8	1,090	840	30%
Loudoun	Round Hill STP	1,540	1,170	32%
Alexandria	Alexandria STP	21,560	16,260	33%
Stafford	Aquia STP	2,730	2,050	33%
Rockingham	Merck-Elkton	83,160	60,580	37%
Rockingham	Pilgrims Pride-Hinton	49,030	26,320	86%
DC	Blue Plains - VA Portion	12,850	6,850	88%
Rockingham	SIL Clean Water STP	105,210	21,450	390%
Page	Luray STP	17,240	2,930	488%
Fairfax	Upper Occoquan S.A.	5,450	860	534%
Clarke	Berryville STP	4,230	NA	NA
Rockingham	Coors	11,490	NA	NA
Rockingham	Massanutten PSA STP	7,410	NA	NA
Frederick	Parkins Mill STP	34,960	NA	NA
King George	USNSWC-Dahlgren STP	4,560	NA	NA
Fauquier	Vint Hill STP	120	NA	NA
	Basin Total =	**521,950**	**762,680**	**-32%**

Table A-3: RAPPAHANNOCK RIVER BASIN
2003 POINT SOURCE NITROGEN DISCHARGE INVENTORY

LOCATION	FACILITY	2003 TP LOAD DISCH. (LBS/YR)	1985 TP LOAD DISCH. (LBS/YR)	% CHANGE FROM 1985
Lancaster	Kilmarnock STP	4,830	9,680	-50%
Fredericksburg	Fredericksburg STP	100,090	146,300	-32%
Northumberland	Omega Protein	44,510	50,130	-11%
Stafford	Little Falls Run STP	56,200	50,090	12%
Spotsylvania	Massaponax STP	105,650	88,230	20%
Essex	Tappahannock STP	15,310	12,520	22%
Northumberland	Reedville STP	2,160	1,710	26%
Fauquier	Remington STP	13,870	10,250	35%
Culpeper	Culpeper STP	73,370	52,560	40%
Caroline	Ft. A.P. Hill - Wilcox STP	4,990	2,960	69%
Orange	Orange STP	59,650	34,720	72%
Fauquier	Warrenton STP	102,870	59,770	72%
Middlesex	Urbanna STP	5,230	2,850	84%
Richmond	Warsaw STP	12,120	4,550	166%
Richmond	Haynesville CC STP	3,960	850	366%
Orange	Wilderness STP	33,040	NA	NA
Spotsylvania	FMC STP	49,120	NA	NA
Westmoreland	Montross STP	1,290	NA	NA
	Basin Total =	**688,260**	**552,910**	**24%**

Table A-4: RAPPAHANNOCK RIVER BASIN
2003 POINT SOURCE PHOSPHORUS DISCHARGE INVENTORY

LOCATION	FACILITY	2003 TP LOAD DISCH. (LBS/YR)	1985 TP LOAD DISCH. (LBS/YR)	% CHANGE FROM 1985
Caroline	Ft. A.P. Hill - Wilcox STP	130	1,010	-87%
Fredericksburg	Fredericksburg STP	7,830	50,070	-84%
Spotsylvania	Massaponax STP	6,450	29,580	-78%
Essex	Tappahannock STP	1,330	4,290	-69%
Culpeper	Culpeper STP	11,590	32,450	-64%
Fauquier	Warrenton STP	7,860	20,460	-62%
Lancaster	Kilmarnock STP	1,510	3,310	-54%
Northumberland	Reedville STP	290	580	-50%
Stafford	Little Falls Run STP	9,780	17,140	-43%
Orange	Orange STP	7,980	11,880	-33%
Middlesex	Urbanna STP	800	970	-18%
Northumberland	Omega Protein	2,290	2,230	3%
Richmond	Warsaw STP	1,620	1,560	4%
Fauquier	Remington STP	4,510	3,510	28%
Richmond	Haynesville CC STP	530	290	83%
Orange	Wilderness STP	4,420	NA	NA
Spotsylvania	FMC STP	1,510	NA	NA
Westmoreland	Montross STP	270	NA	NA
	Basin Total =	**70,700**	**191,610**	**-63%**

Table A-5: YORK RIVER BASIN
2003 POINT SOURCE NITROGEN DISCHARGE INVENTORY

LOCATION	FACILITY	2003 TN LOAD DISCH. (LBS/YR)	1985 TN LOAD DISCH. (LBS/YR)	% CHANGE FROM 1985
Orange	Gordonsville STP	11,590	31,310	-63%
King William	Smurfitt-Stone	246,250	586,340	-58%
King William	West Point STP	24,080	28,460	-15%
Mathews	Mathews Courthouse STP	1,610	1,710	-6%
Hanover	Ashland STP	34,160	35,050	-3%
Hanover	Doswell STP	65,760	65,550	0%
York	HRSD-York STP	598,930	481,920	24%
Caroline	Caroline Co. STP	16,290	NA	NA
New Kent	Parham Landing STP	1,450	NA	NA
York	Giant -Yorktown Refinery	157,230	157,760	NA
	Basin Total =	**1,157,350**	**1,388,100**	**-17%**

Table A-6: YORK RIVER BASIN
2003 POINT SOURCE PHOSPHORUS DISCHARGE INVENTORY

LOCATION	FACILITY	2003 TP LOAD DISCH. (LBS/YR)	1985 TP LOAD DISCH. (LBS/YR)	% CHANGE FROM 1985
King William	Smurfitt-Stone	45,580	241,530	-81%
Orange	Gordonsville STP	2,650	10,720	-75%
Mathews	Mathews Courthouse STP	170	580	-71%
York	HRSD-York STP	50,260	152,130	-67%
King William	West Point STP	4,020	9,740	-59%
Hanover	Ashland STP	11,710	12,300	-5%
Hanover	Doswell STP	42,870	19,730	117%
Caroline	Caroline Co. STP	1,050	NA	NA
New Kent	Parham Landing STP	140	NA	NA
York	Giant -Yorktown Refinery	13,420	2,220	NA
	Basin Total =	**171,870**	**448,950**	**-62%**

Table A-7: JAMES RIVER BASIN
2003 POINT SOURCE NITROGEN DISCHARGE INVENTORY

LOCATION	FACILITY	2003 TN LOAD DISCH. (LBS/YR)	1985 TN LOAD DISCH. (LBS/YR)	% CHANGE FROM 1985
Prince Edward	Farmville STP	1,740	27,110	-94%
Hanover	Tyson Foods-Glen Allen	19,110	132,470	-86%
Hopewell	Honeywell Co.-Hopewell	905,390	4,460,620	-80%
Hopewell	Hopewell STP	1,314,820	6,101,060	-78%
Rockbridge	Lex-Rockbridge Reg. STP	14,870	49,520	-70%
Campbell	BWX-Tech NNFD	244,560	728,250	-66%
Norfolk	HRSD-VIP STP	851,980	1,866,760	-54%
Chesterfield	Falling Creek STP	302,920	637,370	-52%
Alleghany	MeadWestvaco	320,190	554,760	-42%
Petersburg	So. Central W.W.A. STP	312,740	513,180	-39%
Lynchburg	Lynchburg STP	323,110	460,840	-30%
Chesterfield	Philip Morris	108,410	152,500	-29%
James City	HRSD-Williamsburg STP	450,110	632,010	-29%
Chesterfield	Brown & Williamson	35,230	49,350	-29%
Rockbridge	Lees Commercial Carpet	18,040	24,380	-26%
Chesterfield	DuPont-Spruance	167,020	183,890	-9%
Buena Vista	Buena Vista STP	107,230	107,020	0%
Newport News	HRSD-Boat Harbor STP	1,083,140	1,077,400	1%
Norfolk	HRSD-Army Base STP	869,120	773,450	12%
Alleghany	Covington STP	123,870	109,300	13%
Clifton Forge	Clifton Forge STP	73,780	64,890	14%
Nottaway	Crewe STP	14,430	11,400	27%
Newport News	HRSD-James River STP	956,780	725,030	32%
Chesterfield	Proctors Creek STP	373,180	258,100	45%
Virginia Beach	HRSD-Ches/Eliz STP	1,446,260	995,790	45%
Suffolk	HRSD-Nansemond STP	1,349,990	896,890	51%
Albemarle	RWSA-Moores Creek STP	627,280	288,990	117%
Fluvanna	Lake Monticello STP	43,890	13,840	217%
Bedford	Georgia-Pacific	216,440	54,960	294%
Amherst	Amherst STP	13,290	NA	NA
New Kent	Chickahominy WWTP	770	NA	NA
Amherst	Greif Brothers	128,570	NA	NA
Henrico	Henrico STP	1,571,030	NA	NA
Bath	Hot Springs STP	21,750	NA	NA
Norfolk	J.H. Miles	120,240	NA	NA
Powhatan	Powhatan CC STP	15,460	NA	NA
Richmond	Richmond STP	2,486,970	2,462,870	NA
	Basin Total =	**17,033,710**	**24,414,000**	**-30%**

Table A-8: JAMES RIVER BASIN
2003 POINT SOURCE PHOSPHORUS DISCHARGE INVENTORY

LOCATION	FACILITY	2003 TP LOAD DISCH. (LBS/YR)	1985 TP LOAD DISCH. (LBS/YR)	% CHANGE FROM 1985
Nottaway	Crewe STP	200	3,900	-95%
Norfolk	HRSD-VIP STP	36,160	381,990	-91%
Chesterfield	Philip Morris	8,670	60,580	-86%
Suffolk	HRSD-Nansemond STP	75,020	349,080	-79%
Newport News	HRSD-Boat Harbor STP	59,480	260,550	-77%
Alleghany	Covington STP	8,940	37,410	-76%
Lynchburg	Lynchburg STP	48,760	196,310	-75%
Petersburg	So. Central W.W.A. STP	36,050	144,560	-75%
Chesterfield	Brown & Williamson	3,430	13,600	-75%
Newport News	HRSD-James River STP	67,560	258,780	-74%
Chesterfield	Falling Creek STP	38,160	140,340	-73%
Hopewell	Hopewell STP	57,490	175,440	-67%
Rockbridge	Lex-Rockbridge Reg. STP	5,740	16,950	-66%
Norfolk	HRSD-Army Base STP	64,550	177,940	-64%
Virginia Beach	HRSD-Ches/Eliz STP	103,510	284,140	-64%
Rockbridge	Lees Commercial Carpet	14,770	37,870	-61%
Buena Vista	Buena Vista STP	14,340	36,630	-61%
Chesterfield	DuPont-Spruance	8,840	22,200	-60%
James City	HRSD-Williamsburg STP	65,780	112,440	-41%
Clifton Forge	Clifton Forge STP	16,380	22,210	-26%
Chesterfield	Proctors Creek STP	57,160	55,550	3%
Hopewell	Honeywell Co.-Hopewell	33,120	29,320	13%
Prince Edward	Farmville STP	11,160	9,280	20%
Albemarle	RWSA-Moores Creek STP	110,910	90,860	22%
Fluvanna	Lake Monticello STP	5,870	4,740	24%
Bedford	Georgia-Pacific	87,520	32,120	172%
Campbell	BWX-Tech NNFD	1,880	410	359%
Hanover	Tyson Foods-Glen Allen	910	140	550%
Alleghany	MeadWestvaco	263,430	20,110	1210%
Amherst	Amherst STP	1,780	NA	NA
New Kent	Chickahominy WWTP	100	NA	NA
Amherst	Greif Brothers	65,810	NA	NA
Henrico	Henrico STP	222,380	NA	NA
Bath	Hot Springs STP	2,910	NA	NA
Norfolk	J.H. Miles	12,100	NA	NA
Powhatan	Powhatan CC STP	4,250	NA	NA
Richmond	Richmond STP	108,740	839,070	NA
	Basin Total =	**1,723,860**	**3,814,520**	**-55%**

Table A-9: EASTERN SHORE BASIN
2003 POINT SOURCE NITROGEN DISCHARGE INVENTORY

LOCATION	FACILITY	2003 TN LOAD DISCH. (LBS/YR)	1985 TN LOAD DISCH. (LBS/YR)	% CHANGE FROM 1985
Accomack	Tangier STP	2,100	3,420	-39%
Accomack	Tyson-Temperanceville	206,070	277,400	-26%
Accomack	Onancock STP	11,790	6,260	88%
Northampton	Cape Charles STP	9,940	NA	NA
Northampton	Shore Health Services STP	4,220	NA	NA
	Basin Total =	**234,120**	**287,080**	**-18%**

Table A-10: EASTERN SHORE BASIN
2003 POINT SOURCE PHOSPHORUS DISCHARGE INVENTORY

LOCATION	FACILITY	2003 TP LOAD DISCH. (LBS/YR)	1985 TP LOAD DISCH. (LBS/YR)	% CHANGE FROM 1985
Accomack	Tyson-Temperanceville	2,710	36,530	-93%
Accomack	Tangier STP	610	1,170	-48%
Accomack	Onancock STP	1,760	2,140	-18%
Northampton	Cape Charles STP	1,330	NA	NA
Northampton	Shore Health Services STP	1,270	NA	NA
	Basin Total =	**7,680**	**39,840**	**-81%**